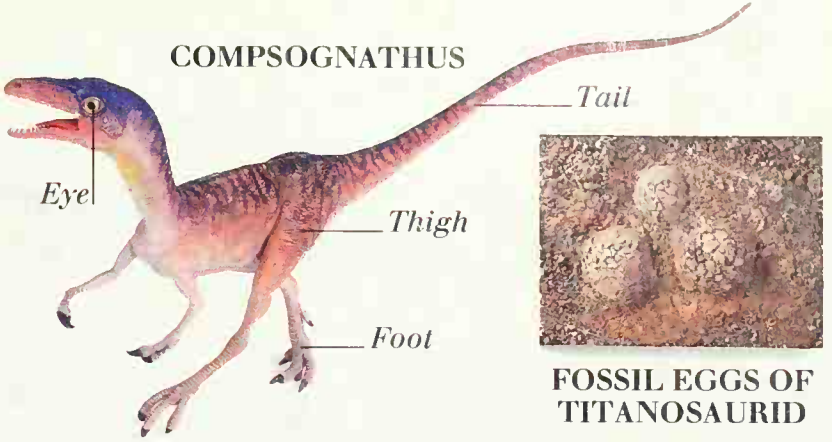
EYEWITNESS VISUAL DICTIONARIES

# THE VISUAL DICTIONARY *of* DINOSAURS

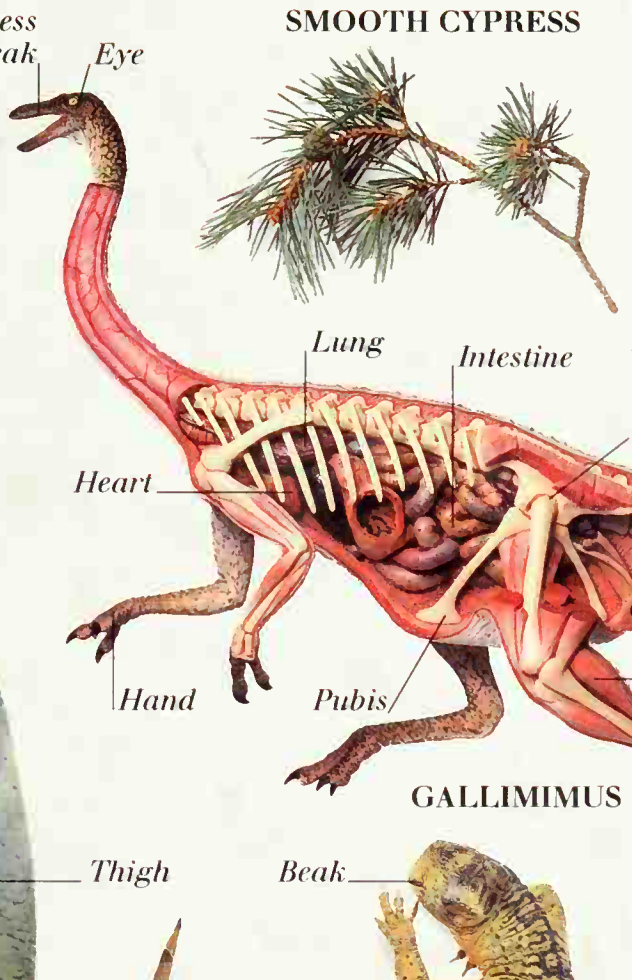




FOSSIL EGGS OF TITANOSAURID

SKELETON OF FOOT OF CHIROSTENOTES

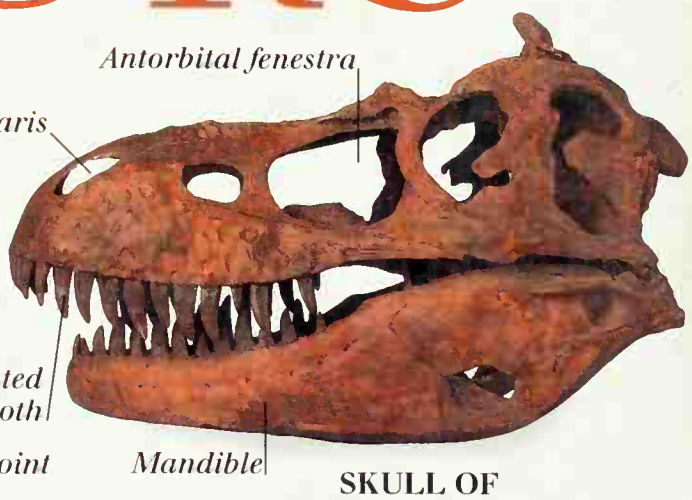


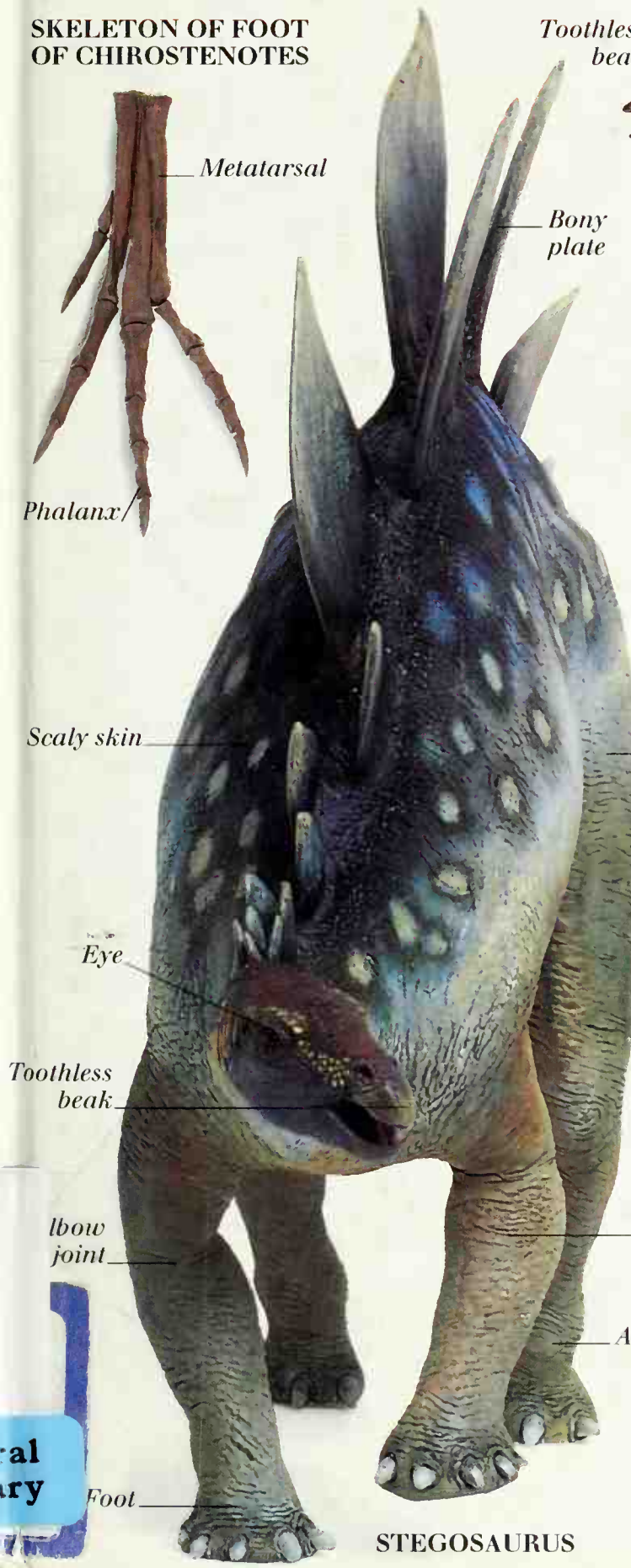

GALLIMIMUS

SMOOTH CYPRESS

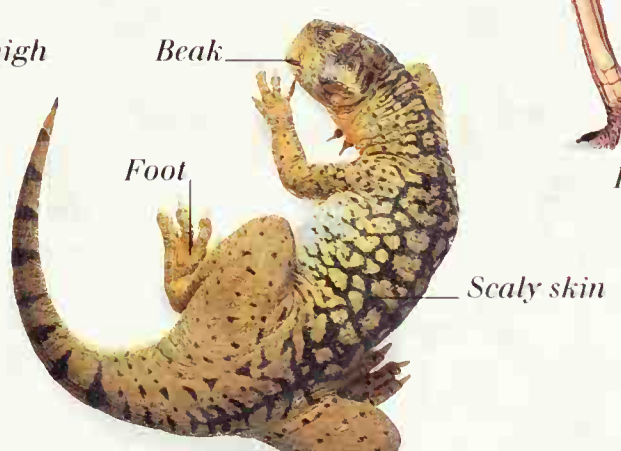




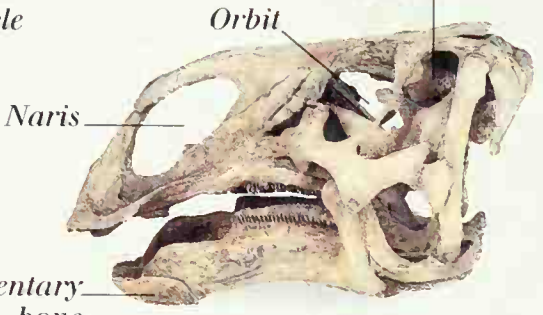

SKULL OF ALBERTOSAURUS




STEGOSAURUS

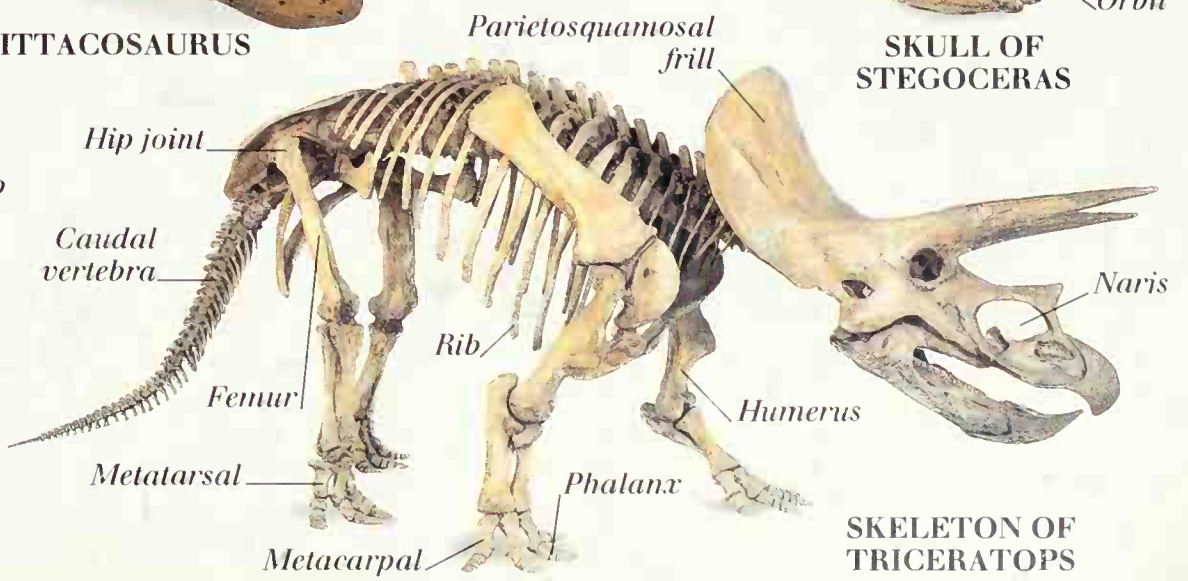



PSITTACOSAURUS




SKULL OF BRACHYLOPHOSAURUS

SKULL OF STEGOCERAS

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EYEWITNESS VISUAL DICTIONARIES

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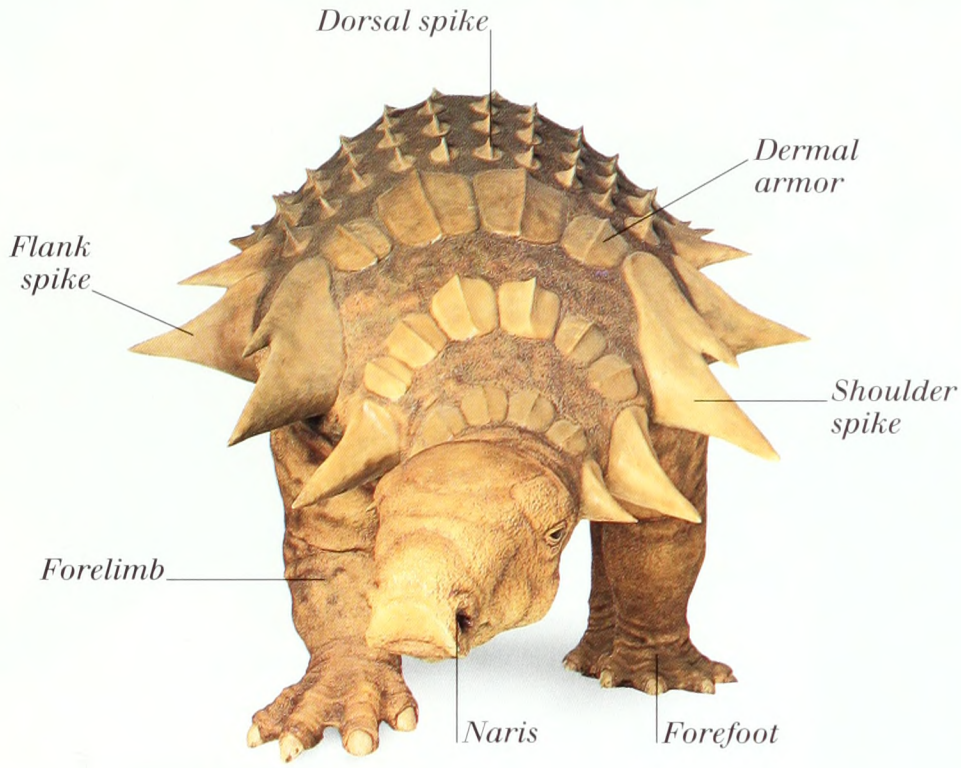
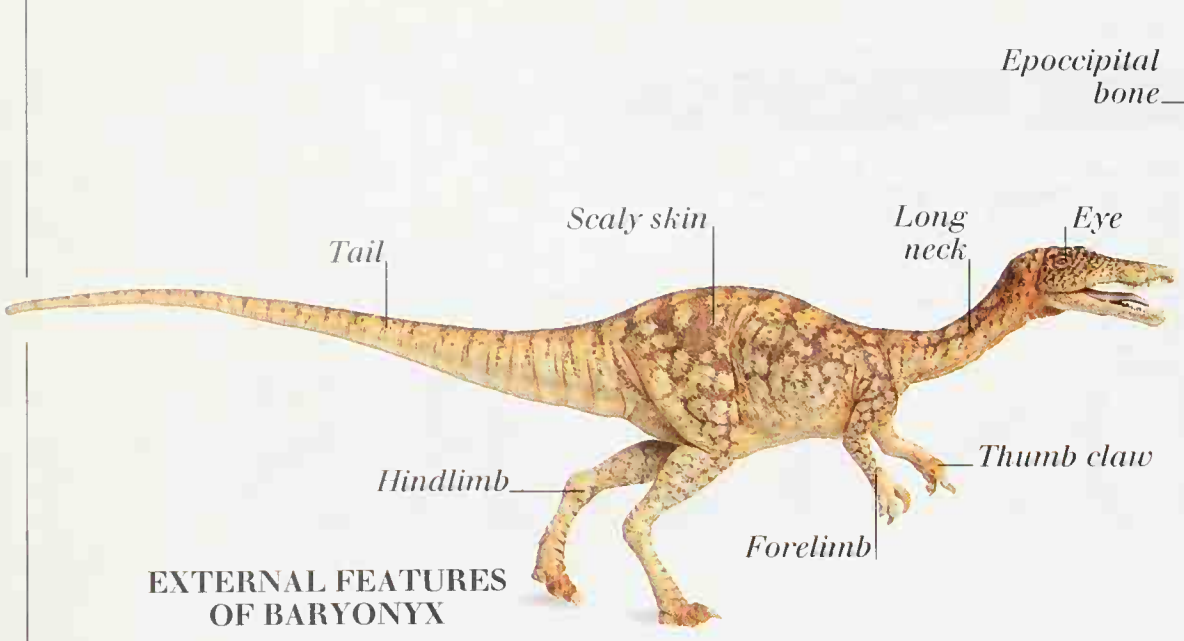
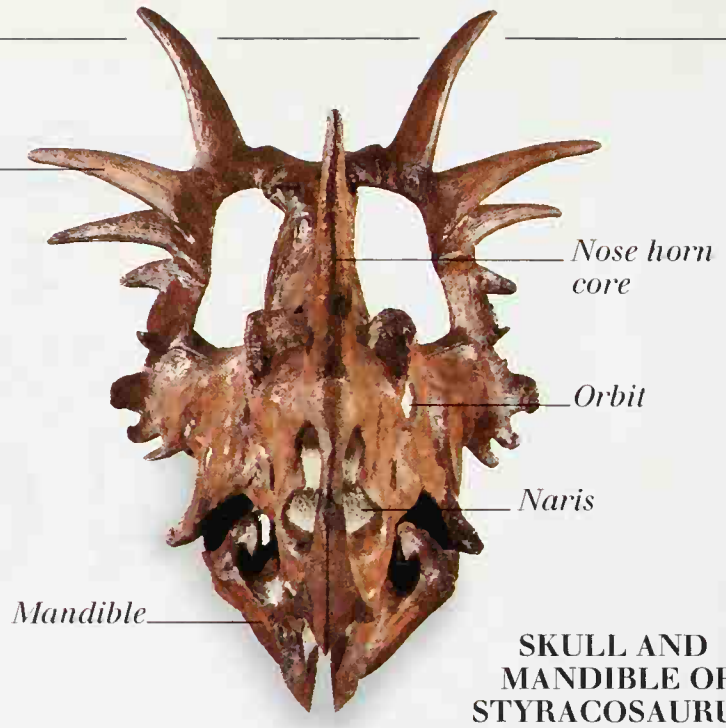


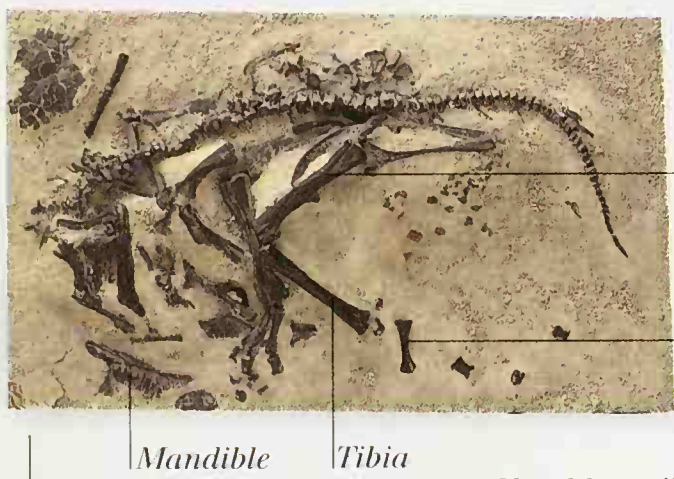

**EXTERNAL FEATURES OF EDMONTONIA**



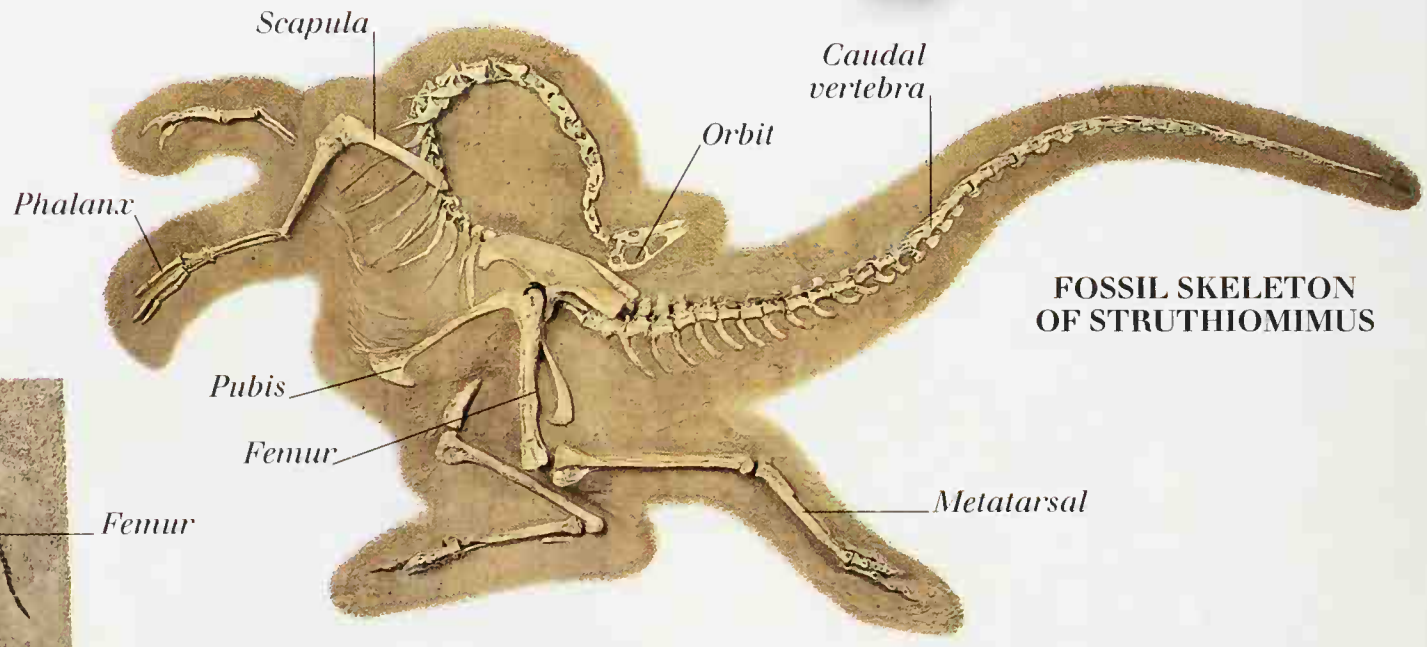

EXTERNAL FEATURES OF BARYONYX



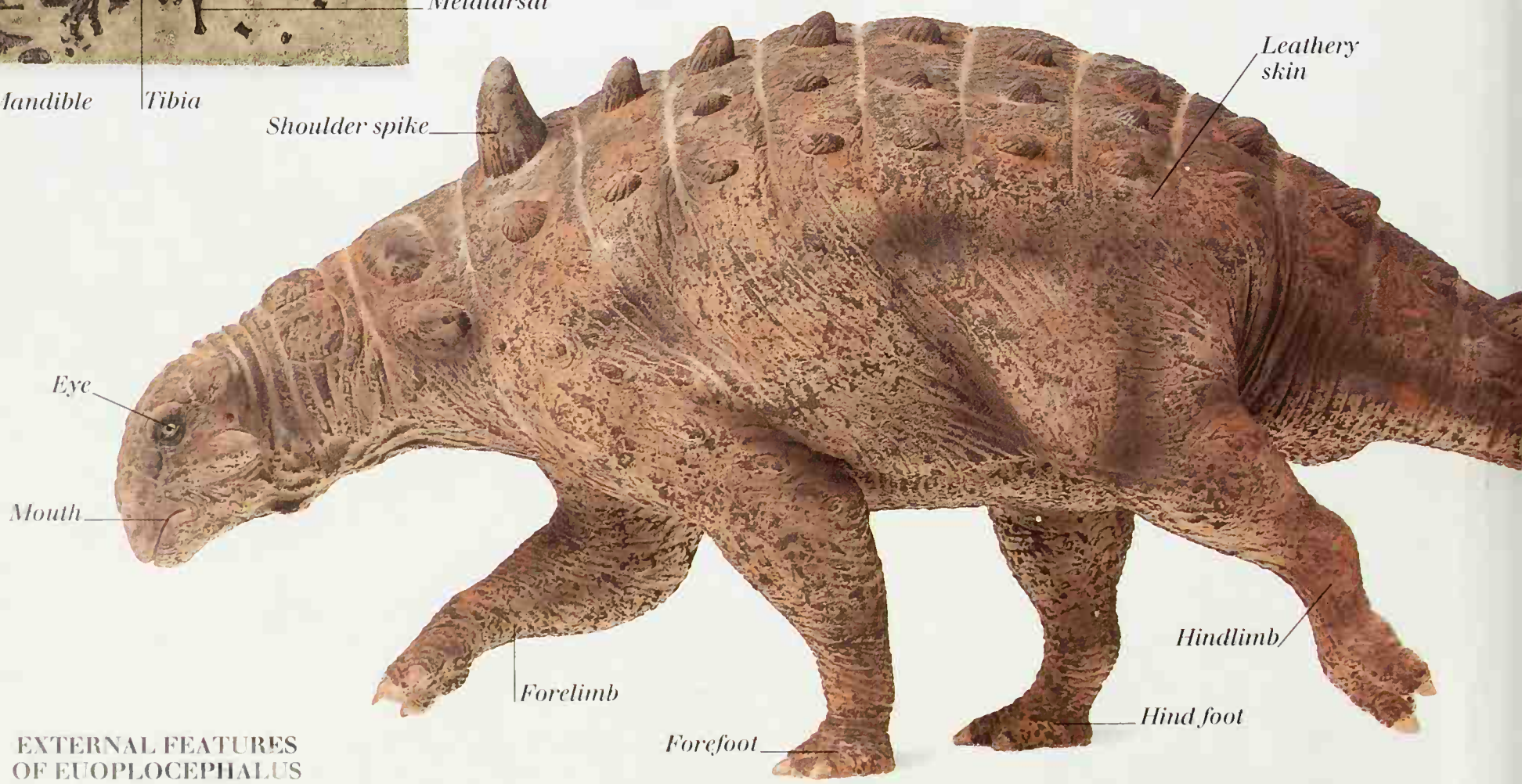

SKULL AND MANDIBLE OF STYRACOSAURUS




FOSSIL SKELETON OF YOUNG HADROSAUR




FOSSIL SKELETON OF STRUTHIOMIMUS




EXTERNAL FEATURES OF EUOPLOCEPHALUS

EYEWITNESS VISUAL DICTIONARIES

# THE VISUAL DICTIONARY *of* DINOSAURS

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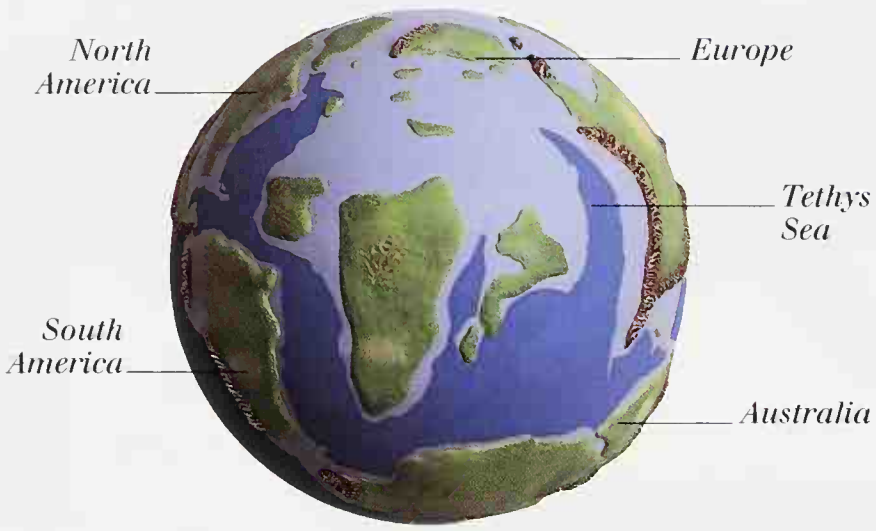


THE EARTH DURING THE CRETACEOUS PERIOD

First American Edition, 1993

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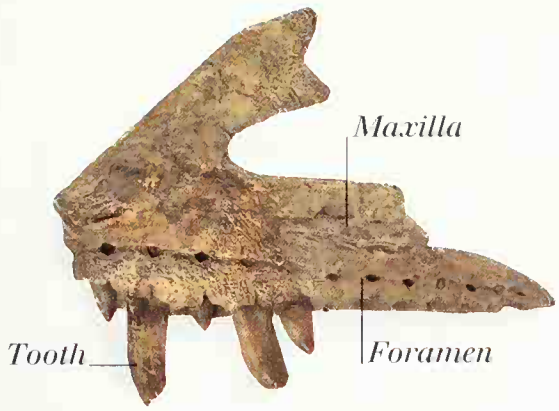


**UPPER JAW OF TERATOSAURUS**

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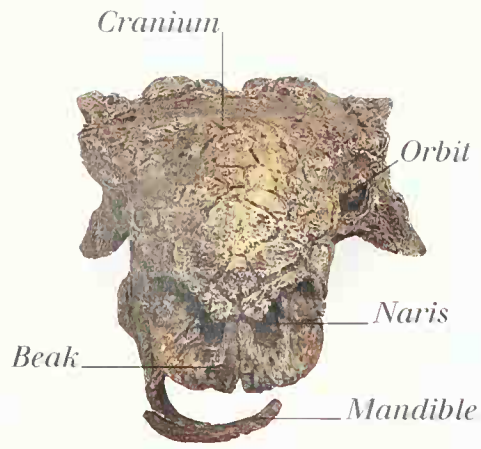
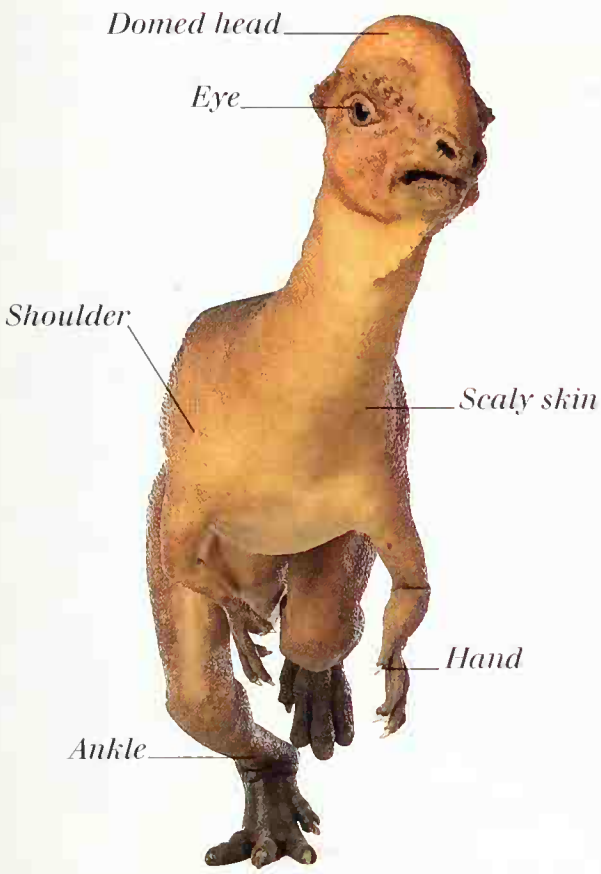
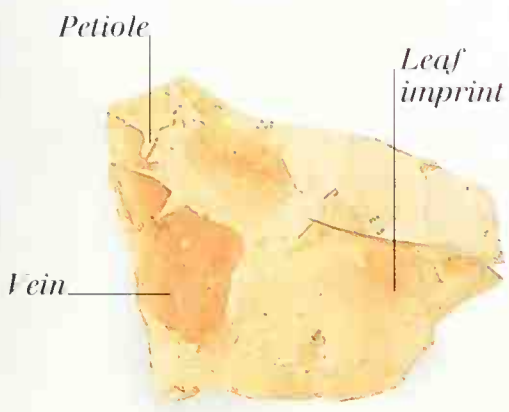



**SKULL AND MANDIBLE OF EUOPLOCEPHALUS**

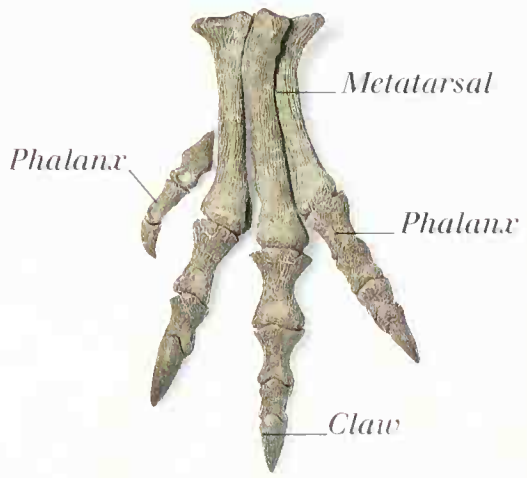



**EXTERNAL FEATURES OF STEGOCERAS**

**EXTERNAL FEATURES OF BAROSAURUS**



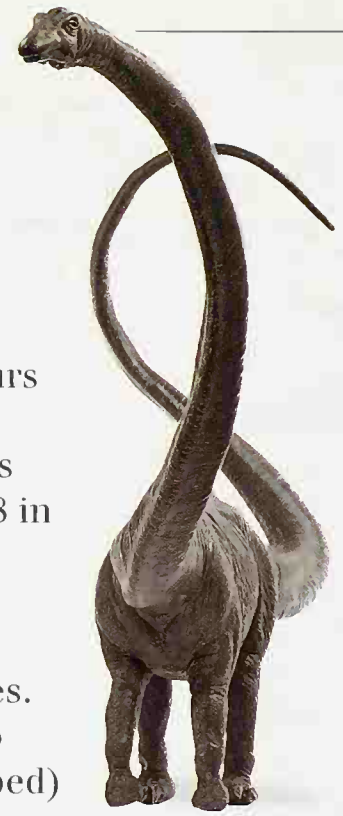

**FOSSILIZED LEAF OF CRETACEOUS TREE**




**MODEL OF FOOT OF BARYONYX**

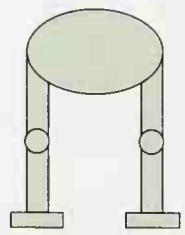
# The dinosaurs

DINOSAURS WERE A LARGE GROUP OF REPTILES that were the dominant land vertebrates (animals with backbones) on Earth from the first part of the Late Triassic (231 million years ago) to the end of the Cretaceous period (65 million years ago). Dinosaurs were diverse, ranging from huge herbivores (plant-eaters) such as *Barosaurus*, which was 90 ft (27.4 m) long, to small carnivores (flesh-eaters) such as *Compsognathus*, which was less than 4 ft 8 in (1.4 m) long. Two features that most dinosaurs had in common were raised metatarsals and an erect stance. Their erect stance enabled dinosaurs to keep their bodies well above the ground, unlike the sprawling and semi-sprawling stances of other reptiles. Dinosaurs can be categorized into two main groups according to the structure of their pelvis (hip bones): ornithischian (bird-hipped) and saurischian (lizard-hipped) dinosaurs. Ornithischians had a relatively long, shallow ilium and a backward-slanting pubis. Most saurischians had a shorter, deeper ilium and a forward-slanting pubis. A third, small group of dinosaurs, the herrerasaurs, had pelvic bones similar to those of saurischians.



**BAROSAURUS**
A saurischian dinosaur

**COMPARISON OF ANIMAL STANCES**



**ERECT STANCE**
The thighs and upper arms project straight down from the body, so that the knees and elbows are straight.

**SKELETON OF LOWER LEG OF TYRANNOSAURUS**

*Tibia*

*Fibula*

*Ankle joint*

*Raised metatarsal*

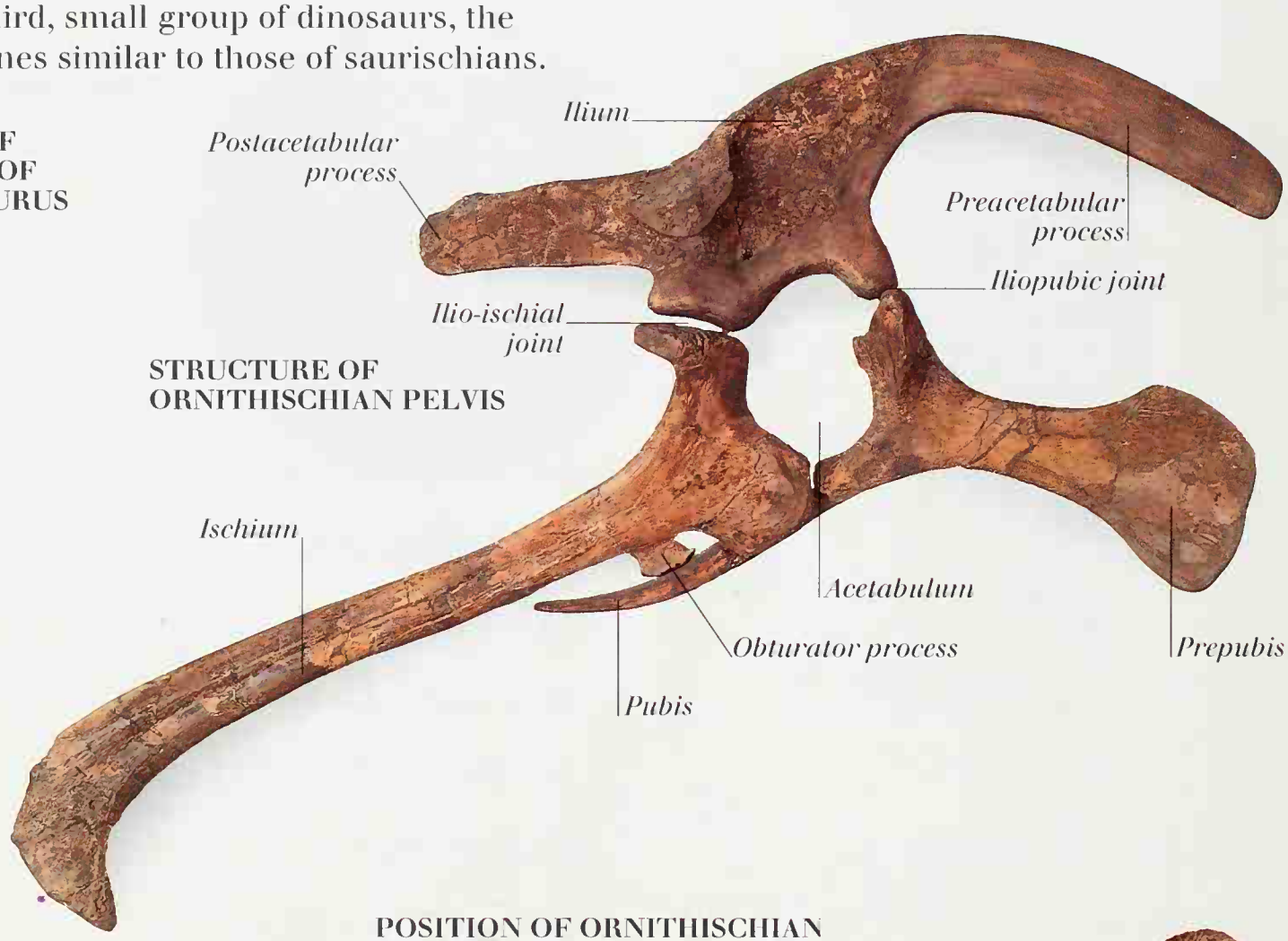
*Metatarsophalangeal joint*

*Phalanx*

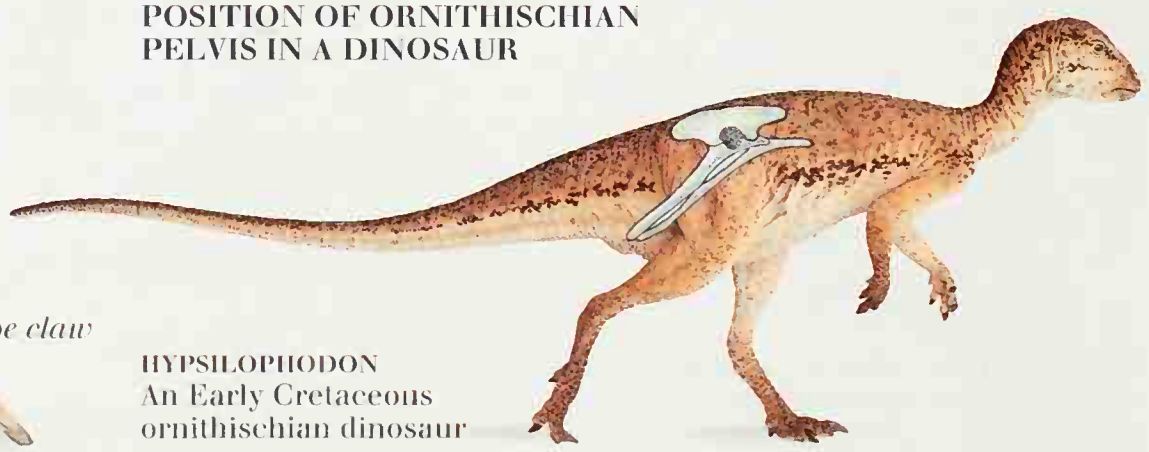
*Interphalangeal joint*

*Reversed hallux (first toe)*

*Toe claw*

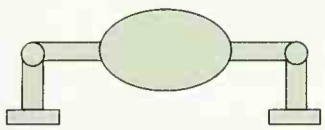



**STRUCTURE OF ORNITHISCHIAN PELVIS**



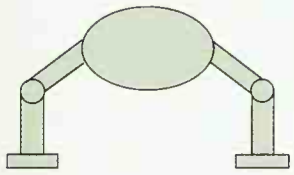
**POSITION OF ORNITHISCHIAN PELVIS IN A DINOSAUR**

**HYPSILOPHODON**
An Early Cretaceous ornithischian dinosaur

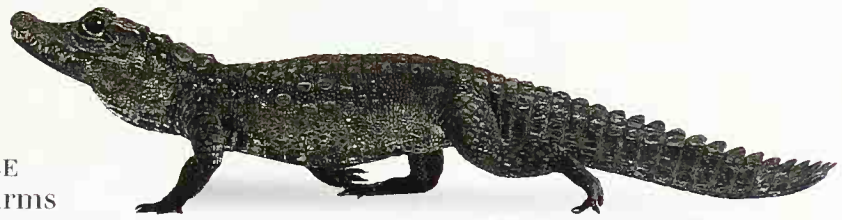


**SPRAWLING STANCE**
The thighs and upper arms project straight out from the body, so that the knees and elbows are bent at right angles.

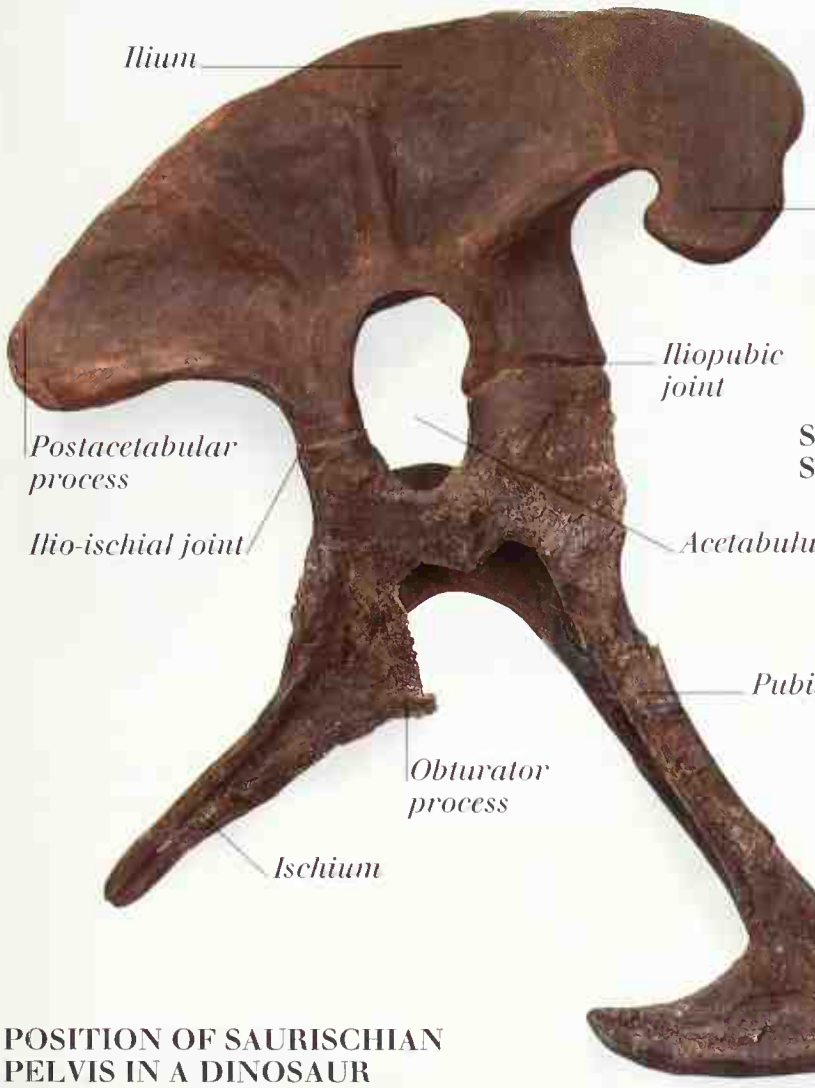
**COMMON IGUANA**
*(Iguana iguana)*
A present-day reptile



**SEMI-SPRAWLING STANCE**
The thighs and upper arms project downward and outward, so that the knees and elbows are slightly bent.

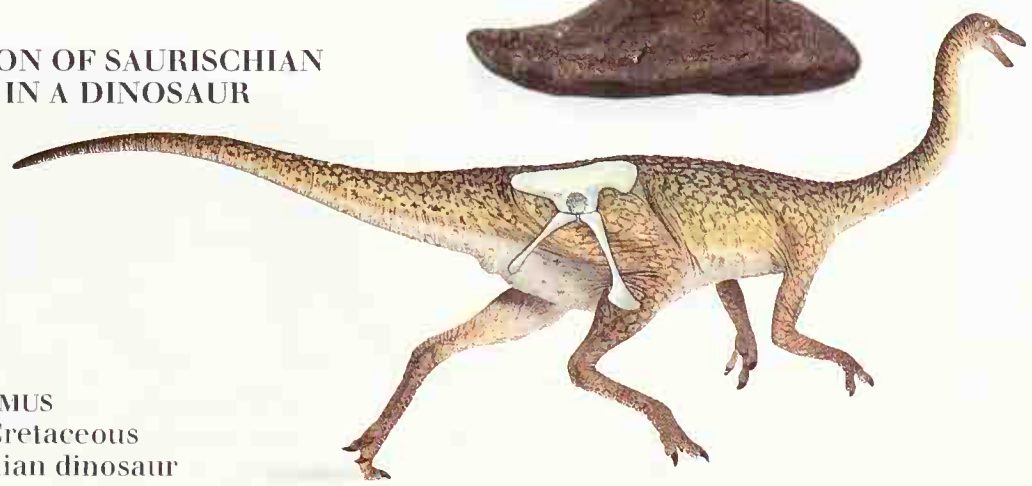


**DWARF CROCODILE**
*(Osteolaemus tetraspis)*
A present-day reptile




**STRUCTURE OF SAURISCHIAN PELVIS**

**POSITION OF SAURISCHIAN PELVIS IN A DINOSAUR**



**GALLIMIMUS**
A Late Cretaceous saurischian dinosaur

## THE GEOLOGICAL TIMESCALE

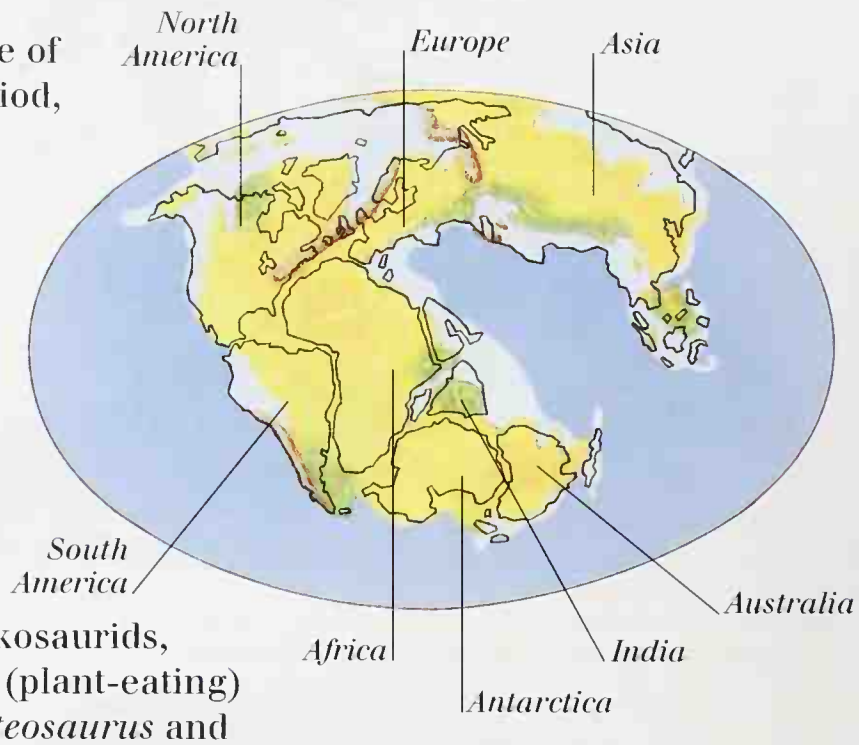
| MYA | PERIOD | ERA |
|---|---|---|
| 2 | QUATERNARY | CENOZOIC |
| | TERTIARY | |
| 65 | CRETACEOUS | MESOZOIC |
| 144 | JURASSIC | |
| 208 | TRIASSIC | |
| 248 | PERMIAN | PALÆOZOIC |
| 286 | CARBONIFEROUS: PENNSYLVANIAN (NORTH AMERICA) | |
| 320 | CARBONIFEROUS: MISSISSIPPIAN (NORTH AMERICA) | |
| 360 | DEVONIAN | |
| 408 | SILURIAN | |
| 438 | ORDOVICIAN | |
| 505 | CAMBRIAN | |
| 550 | PRECAMBRIAN TIME | |
| 4600 | | |

# Triassic period

| | |
|---|---|
| CRETACEOUS 144-65 MYA | MESOZOIC ERA |
| JURASSIC 208-144 MYA | |
| TRIASSIC 248-208 MYA | |

THE TRIASSIC PERIOD (248–208 million years ago) marked the beginning of what is known as the Age of the Dinosaurs (the Mesozoic era). During this period, the present-day continents were massed together, forming one huge continent known as Pangaea. This landmass experienced extremes of climate, with lush green areas around the coast or by lakes and rivers, and arid deserts in the interior. The only forms of plant life were nonflowering plants, such as conifers, ferns, cycads, and ginkgos; flowering plants had not yet evolved. The principal forms of animal life included primitive amphibians, rhynchosaurs ("beaked lizards"), and primitive crocodilians. Dinosaurs first appeared about 230 million years ago, at the beginning of the Late Triassic. The earliest known dinosaurs were the carnivorous (flesh-eating) herrerasaurids and staurikosaurids, such as *Herrerasaurus* and *Staurikosaurus*. Early herbivorous (plant-eating) dinosaurs first appeared in the Late Triassic and included *Plateosaurus* and *Technosaurus*. By the end of the Triassic, dinosaurs dominated Pangaea, possibly contributing to the extinction of many other reptiles.

**TRIASSIC POSITIONS OF PRESENT-DAY LANDMASSES**




**EXAMPLES OF TRIASSIC PLANT GROUPS**

A PRESENT-DAY CYCAD
*(Cycas revoluta)*

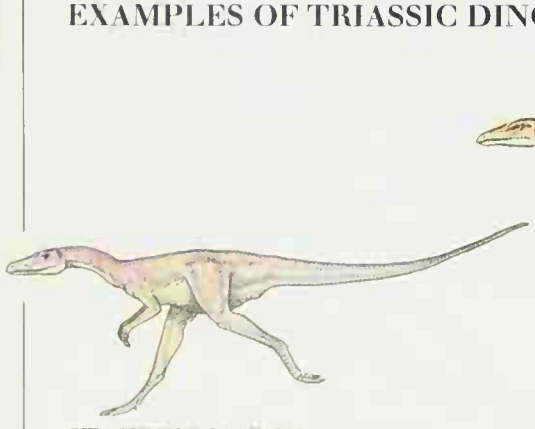
A PRESENT-DAY GINKGO
*(Ginkgo biloba)*

A PRESENT-DAY CONIFER
*(Araucaria araucana)*

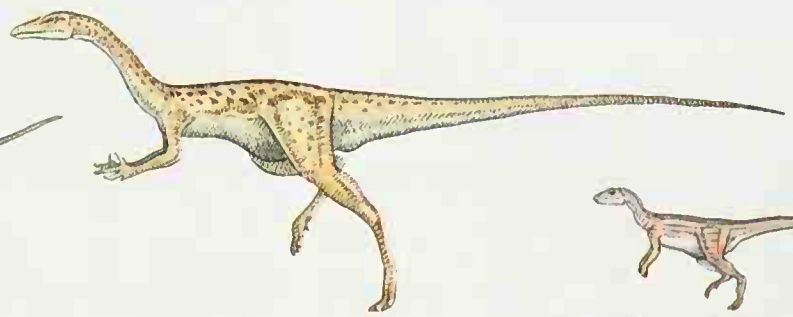
AN EXTINCT FERN
*(Pachypteris* sp.*)*

AN EXTINCT CYCAD
*(Cycas* sp.*)*

**EXAMPLES OF TRIASSIC DINOSAURS**

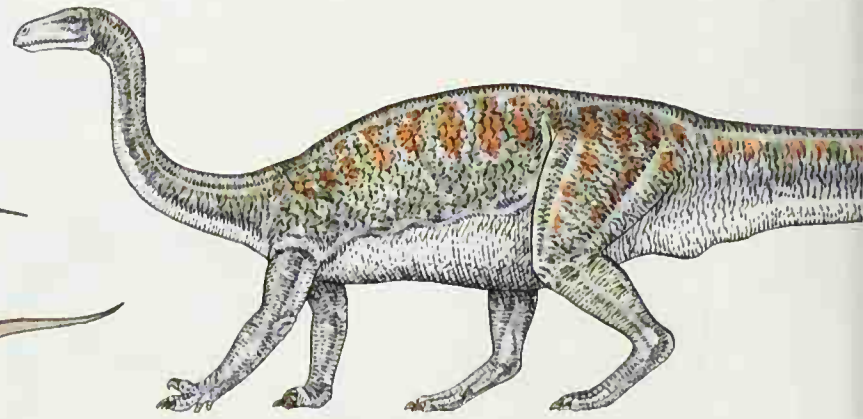


STAURIKOSAURUS
A staurikosaurid
Length: 6 ft 6 in (2 m)



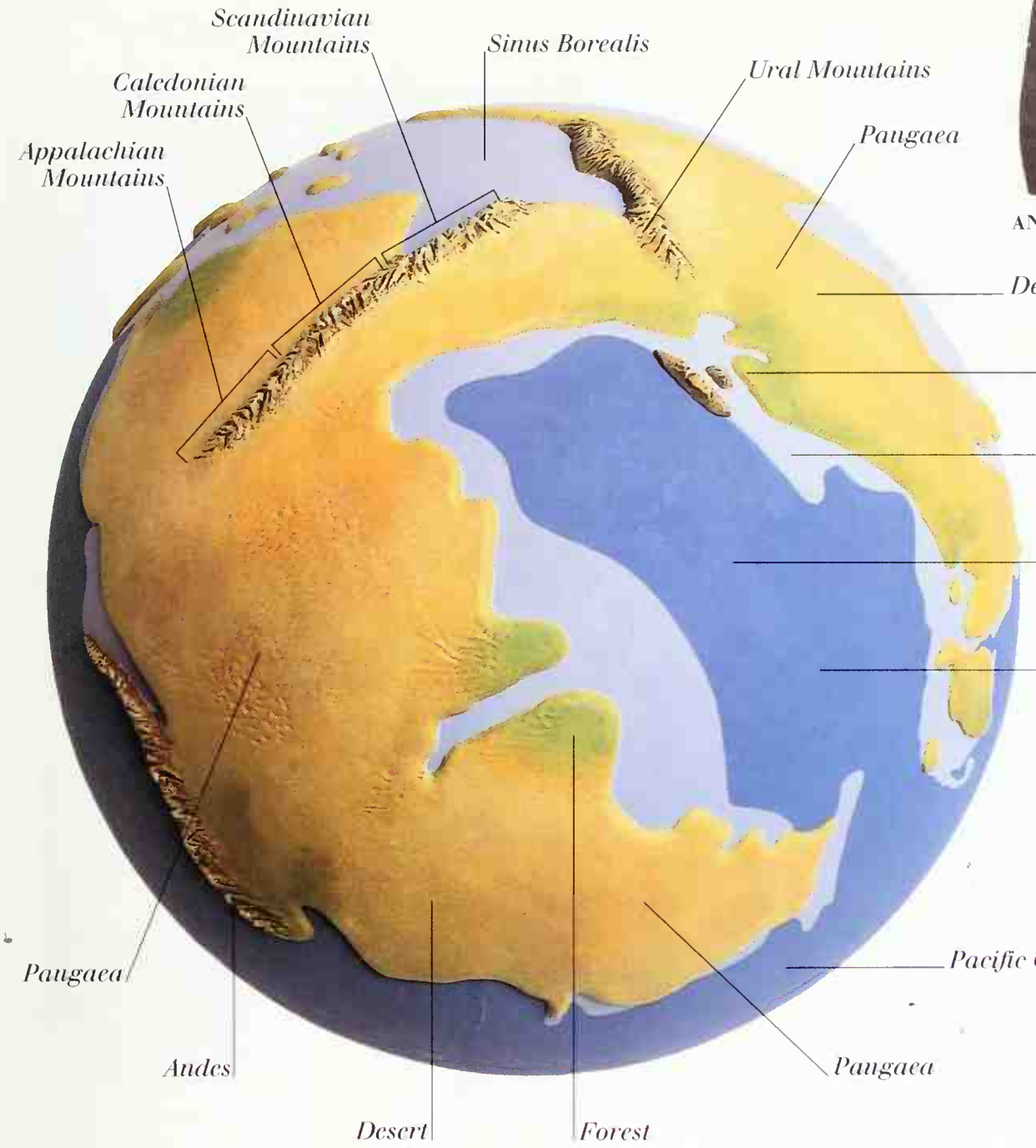
COELOPHYSIS
A coelophysid
Length: 10 ft (3 m)

TECHNOSAURUS
A primitive ornithischian
Length: 3 ft 3 in (1 m)



PLATEOSAURUS
A plateosaurid
Length: 26 ft (7.9 m)

## THE EARTH DURING THE TRIASSIC PERIOD




## EXAMPLES OF TRIASSIC ANIMALS

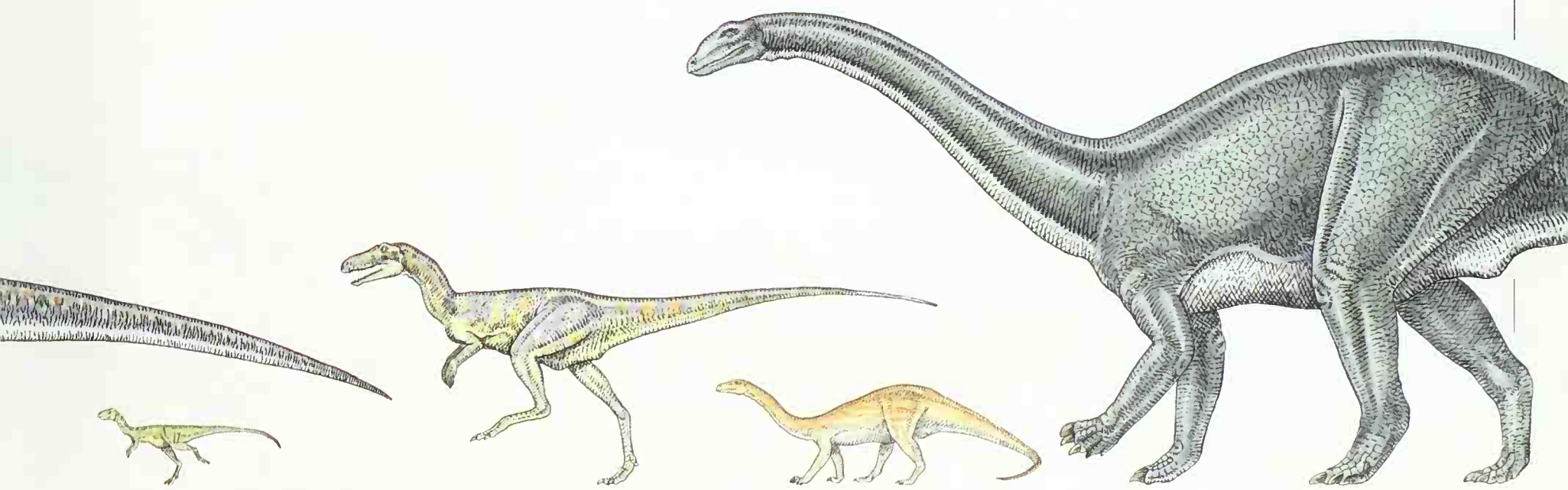
AN EXTINCT AMPHIBIAN

A NAUTILOID MOLLUSK
*(Nautilus* sp.*)*

AN EXTINCT CHONDROSTEAN FISH
*(Cleithrolepis granulatus)*

AN EXTINCT NOTHOSAURIAN REPTILE
*(Pachypleurosaurus* sp.*)*

AN EXTINCT RHYNCHOSAURIAN REPTILE
*(Seaphonyx fischeri)*



**PISANOSAURUS**
A primitive ornithischian
Length: 3 ft (90 cm)

**HERRERASAURUS**
A herrerasaurid
Length: 10 ft (3 m)

**MUSSAURUS**
A plateosaurid
Length: 6 ft 6 in–10 ft (2–3 m)

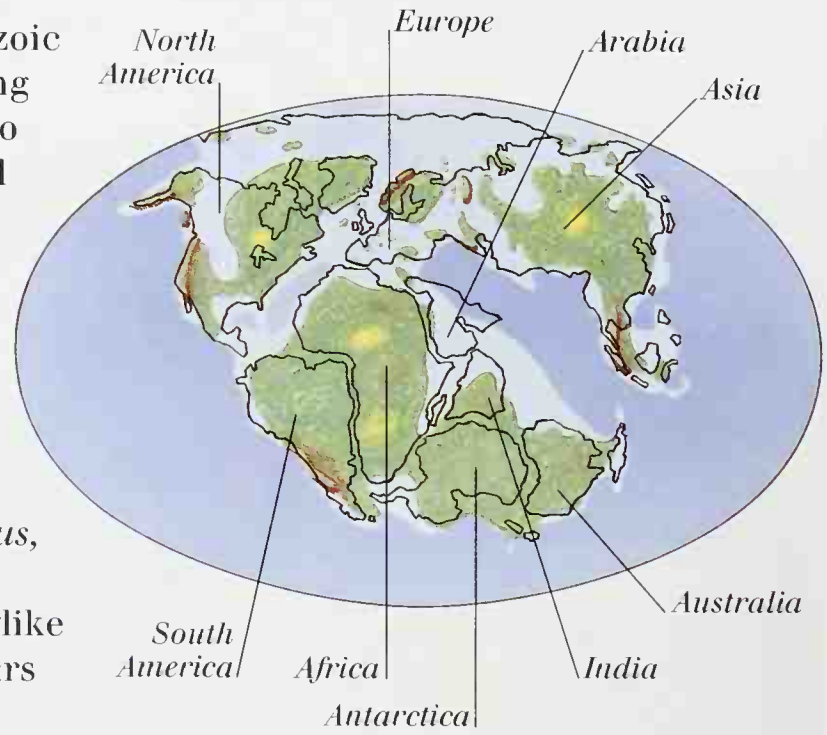
**MELANOROSAURUS**
A melanorosaurid
Length: 40 ft (12.2 m)

# Jurassic period

CRETACEOUS 144-65 MYA
JURASSIC 208-144 MYA
TRIASSIC 248-208 MYA
MESOZOIC ERA

THE JURASSIC PERIOD, the middle part of the Mesozoic era, lasted from 208 to 144 million years ago. During the Jurassic, the landmass of Pangaea broke up into the continents of Gondwanaland and Laurasia, and sea levels rose, flooding areas of lower land. The Jurassic climate was warm and moist. Plants such as ginkgos, horsetails, and conifers thrived, and giant redwood trees appeared, as did the first flowering plants. The abundance of plant food led to the proliferation of herbivorous (plant-eating) dinosaurs, such as the large sauropods (e.g., *Diplodocus*) and stegosaurs (e.g., *Stegosaurus*). Carnivorous (flesh-eating) dinosaurs, such as *Compsognathus* and *Allosaurus*, also flourished by hunting the many animals, including other dinosaurs, that existed. Other Jurassic animals included shrewlike mammals, and pterosaurs (flying reptiles), as well as plesiosaurs and ichthyosaurs (both marine reptiles).

**JURASSIC POSITIONS OF PRESENT-DAY LANDMASSES**




**EXAMPLES OF JURASSIC PLANT GROUPS**

A PRESENT-DAY FERN
*(Dicksonia antarctica)*

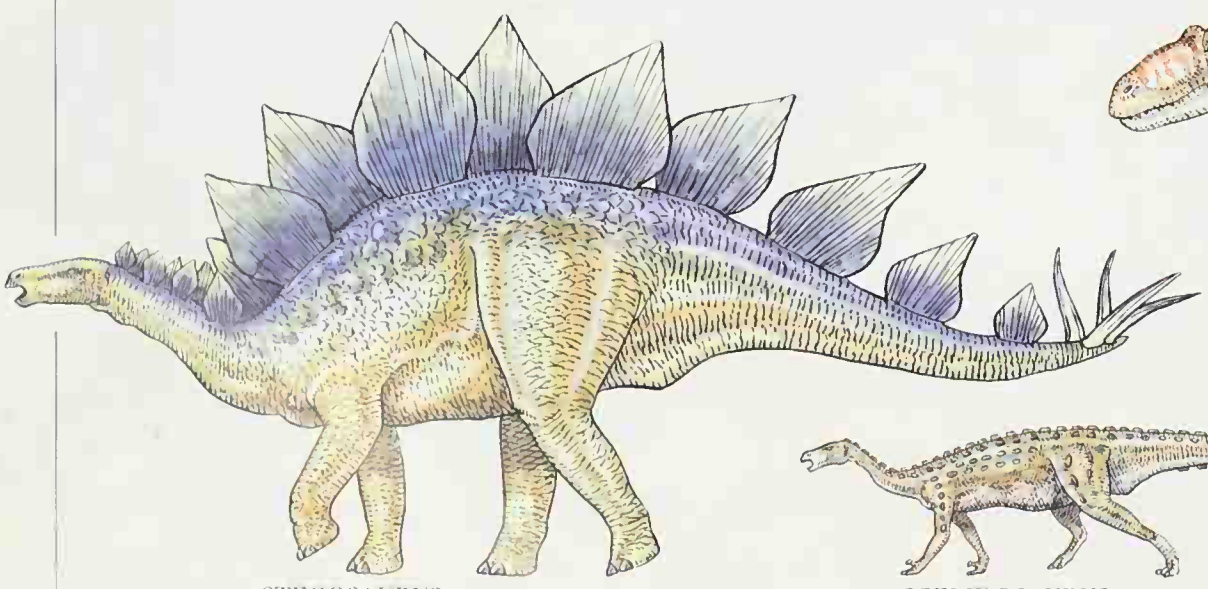
A PRESENT-DAY HORSETAIL
*(Equisetum arvense)*

A PRESENT-DAY CONIFER
*(Taxus baccata)*

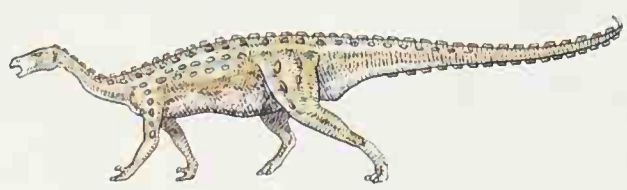
AN EXTINCT CONIFER

AN EXTINCT REDWOOD
*(Sequoiadendron* sp.*)*

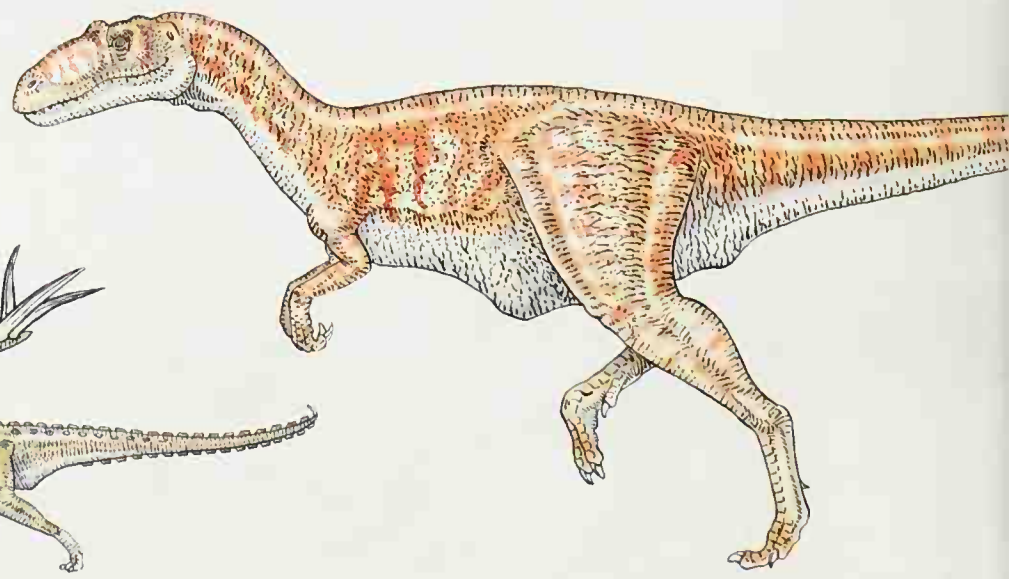
**EXAMPLES OF JURASSIC DINOSAURS**



STEGOSAURUS
A stegosaurid
Length: 30 ft (9.1 m)



SCELIDOSAURUS
A scelidosaurid
Length: 13 ft (4 m)

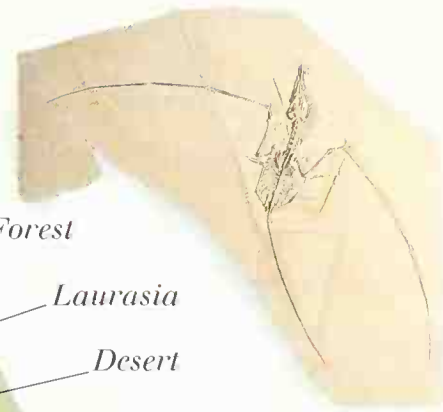


ALLOSAURUS
An allosaurid
Length: 36 ft (11 m)

## THE EARTH DURING THE JURASSIC PERIOD

*Laurasia*
*Laurasia*
*North Atlantic Ocean*
*Ural Mountains*
*Turgai Strait*
*North American Cordillera*
*Forest*
*Laurasia*
*Desert*
*Tethys Sea*
*Deep ocean*
*Continental shelf*
*Desert*
*Forest*
*Andes*
*Gondwanaland*
*Gondwanaland*
*Pacific Ocean*

## EXAMPLES OF JURASSIC ANIMALS

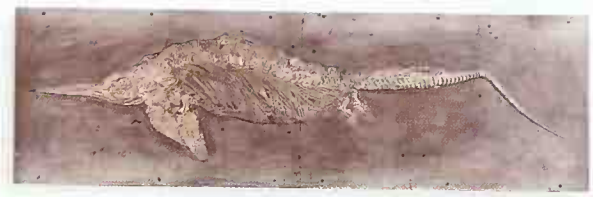


AN EXTINCT PTEROSAUR
*(Rhamphorhynchus* sp.)

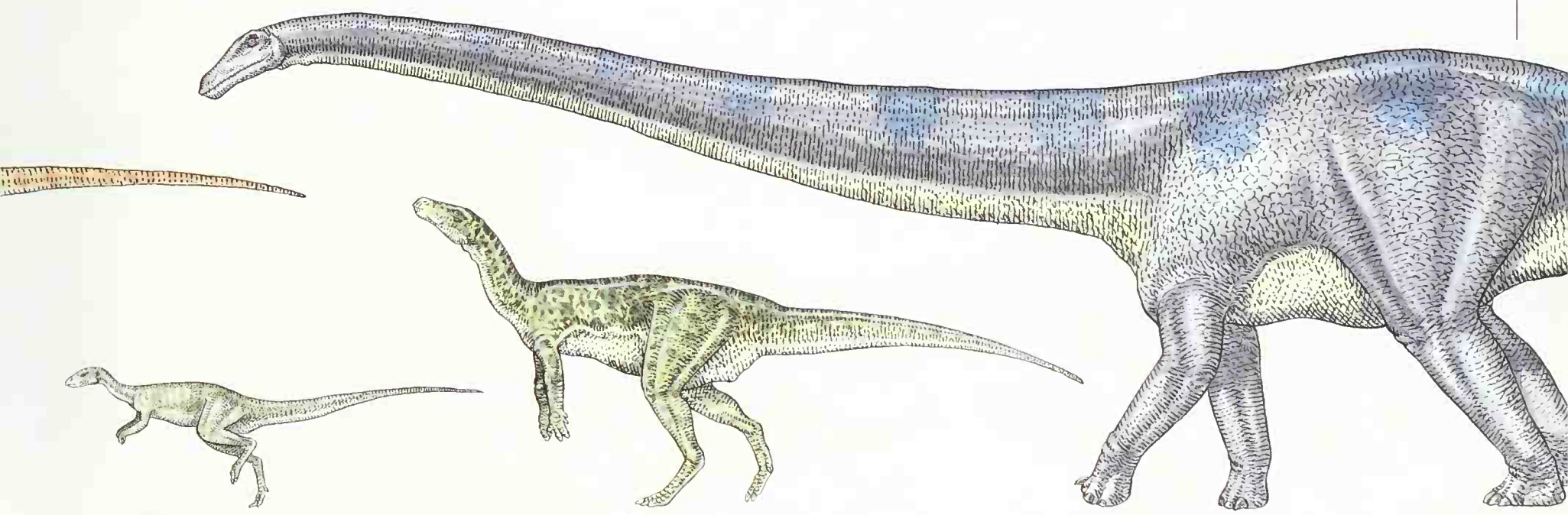
AN EXTINCT
BELEMNITE MOLLUSK
*(Belemnoteuthis* sp.)

AN EXTINCT
RHYNCHOSAURIAN REPTILE
*(Homeosaurus pulchellus)*

AN EXTINCT PLESIOSAUR
*(Peloneustes philarcus)*



AN EXTINCT ICHTHYOSAUR
*(Ichthyosaurus megacephalus)*



DRYOSAURUS
A dryosaurid
Length: 10–13 ft (3–4 m)

CAMPTOSAURUS
A camptosaurid
Length: 16–23 ft (4.9–7 m)

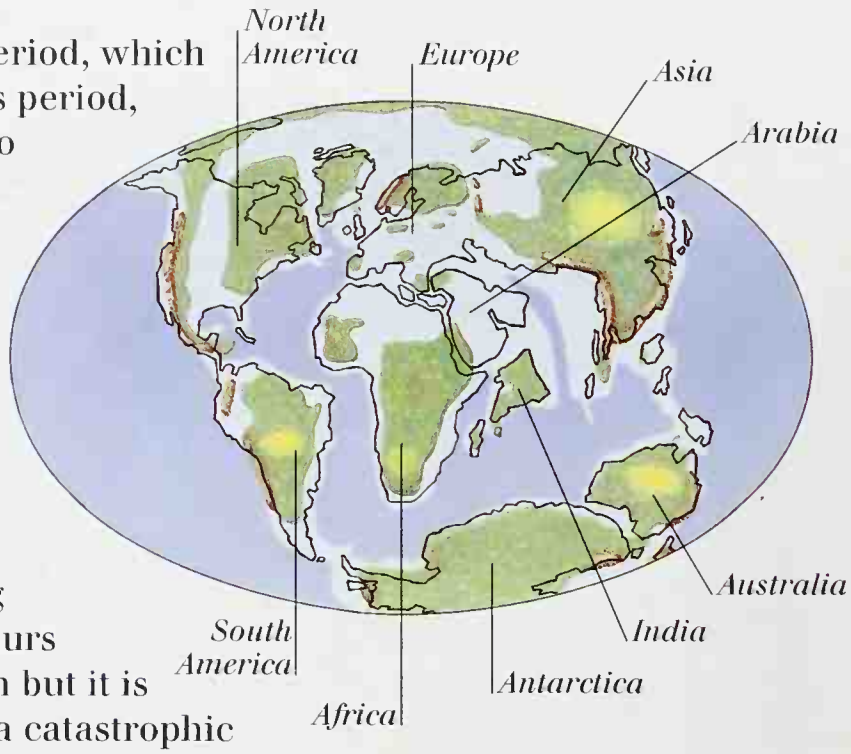
DIPLODOCUS
A diplodocid
Length: 88 ft (26.8 m)

# Cretaceous period

| | |
|---|---|
| CRETACEOUS 144–65 MYA | MESOZOIC ERA |
| JURASSIC 208–144 MYA | |
| TRIASSIC 248–208 MYA | |

THE MESOZOIC ERA ENDED WITH the Cretaceous period, which lasted from 144 to 65 million years ago. During this period, Gondwanaland and Laurasia were breaking up into smaller landmasses that more closely resembled those of the modern continents. The climate remained mild and moist, but the seasons became more marked. Flowering plants, including deciduous trees, replaced many cycads, seed ferns, and conifers. Animal species became more varied, with the evolution of new mammals, insects, fish, crustaceans, and turtles. Dinosaurs evolved into a wide variety of species during the Cretaceous; more than half of all known dinosaurs – including *Iguanodon*, *Deinonychus*, *Tyrannosaurus,* and *Hypsilophodon* – lived during this period. At the end of the Cretaceous, however, large dinosaurs became extinct. The reason for this mass extinction is unknown but it is thought to have been caused by climatic changes due to either a catastrophic meteor impact with the Earth or extensive volcanic eruptions.

**CRETACEOUS POSITIONS OF PRESENT-DAY LANDMASSES**




**EXAMPLES OF CRETACEOUS PLANT GROUPS**

A PRESENT-DAY CONIFER
*(Pinus muricata)*

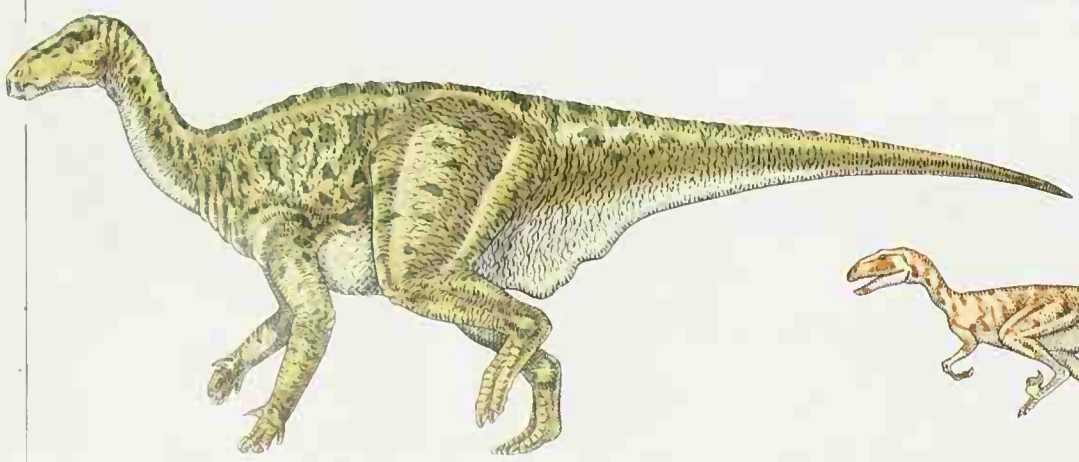
A PRESENT-DAY DECIDUOUS TREE
*(Magnolia* sp.*)*

AN EXTINCT FERN
*(Sphenopteris latiloba)*

AN EXTINCT GINKGO
*(Ginkgo pluripartita)*

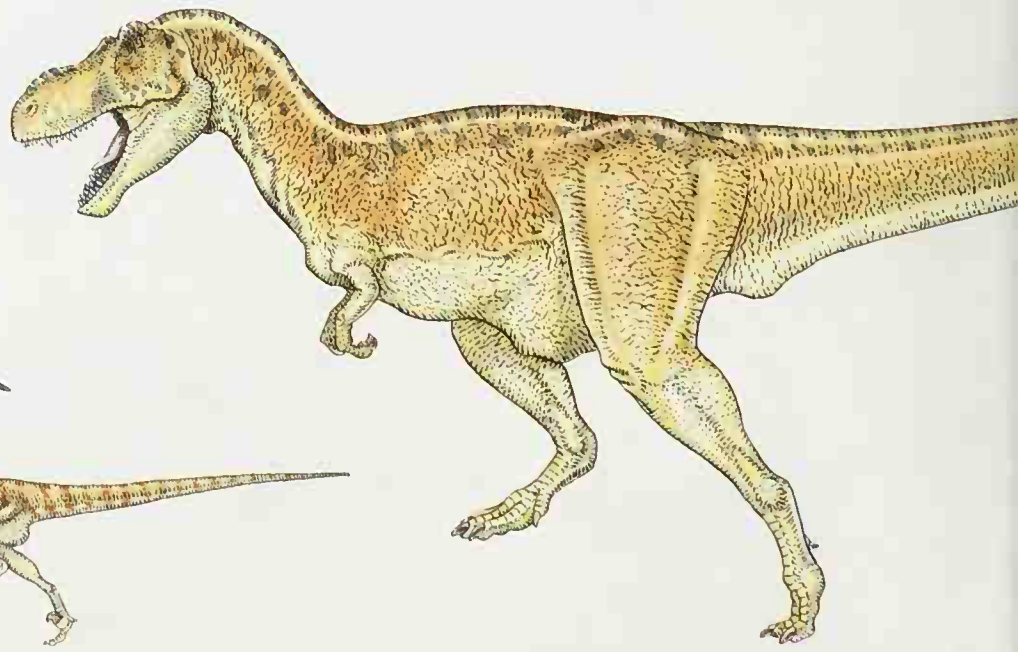
AN EXTINCT DECIDUOUS TREE
*(Cercidyphyllum* sp.*)*

**EXAMPLES OF CRETACEOUS DINOSAURS**



IGUANODON
An iguanodontid
Length: 30 ft (9.1 m)

DEINONYCHUS
A dromaeosaurid
Length: 8–11 ft (2.4–3.4 m)



TYRANNOSAURUS
A tyrannosaurid
Length: 40 ft (12.2 m)

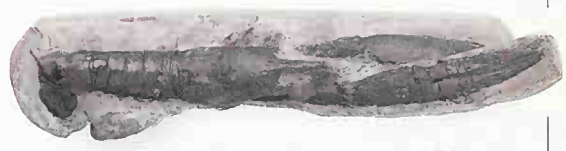
## THE EARTH DURING THE CRETACEOUS PERIOD

*West Africa*
*Greenland*
*North America*
*Africa*
*Europe*
*Continental Sea*
*Ural Mountains*
*Rocky Mountains*
*Desert*
*Tethys Sea*
*Asia*
*India*
*Indian Ocean*
*Australia*
*Pacific Ocean*
*North Atlantic Ocean*
*Andes*
*South America*
*South Atlantic Ocean*
*Antarctica*
*Forest*

## EXAMPLES OF CRETACEOUS ANIMALS

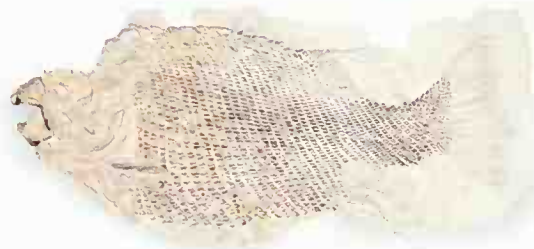
AN EXTINCT INSECT
*(Libellulium longialatum)*

AN EXTINCT MARINE TURTLE
*(Plesiochelys latiscutata)*

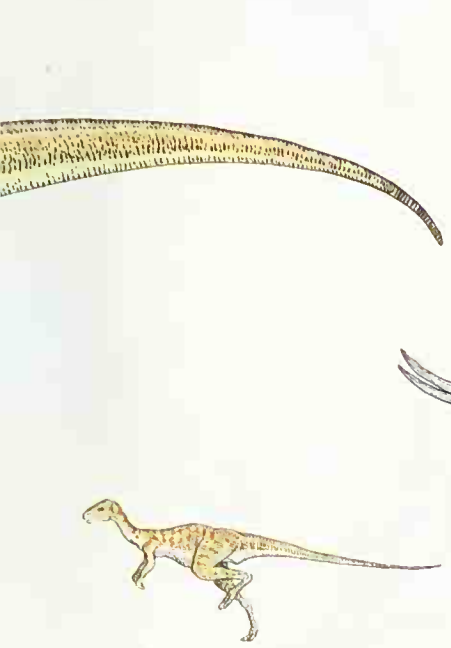


AN EXTINCT CRUSTACEAN
*(Homarus* sp.)

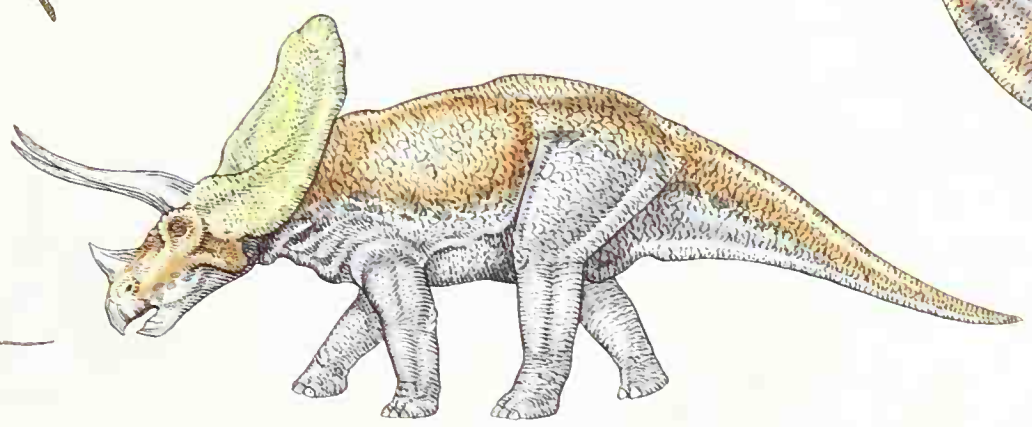
AN EXTINCT CROCODILIAN



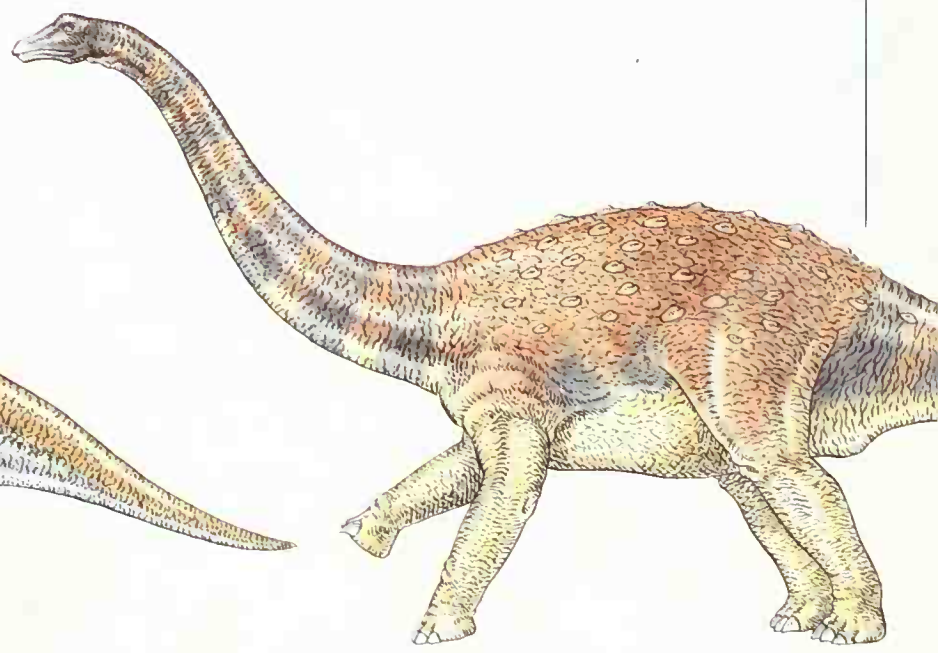
AN EXTINCT HOLOSTEAN FISH
*(Lepidotes maximus)*



**HYPSILOPHODON**
A hypsilophodontid
Length: 4 ft 6 in–7 ft 6 in (1.4–2.3 m)

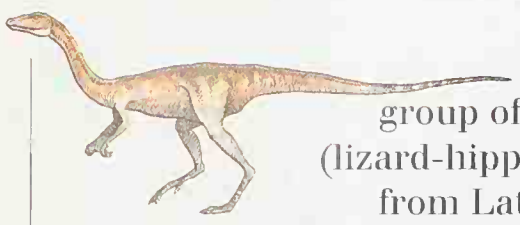


**TOROSAURUS**
A ceratopsid
Length: 25 ft (7.6 m)



**SALTASAURUS**
A titanosaurid
Length: 40 ft (12.2 m)

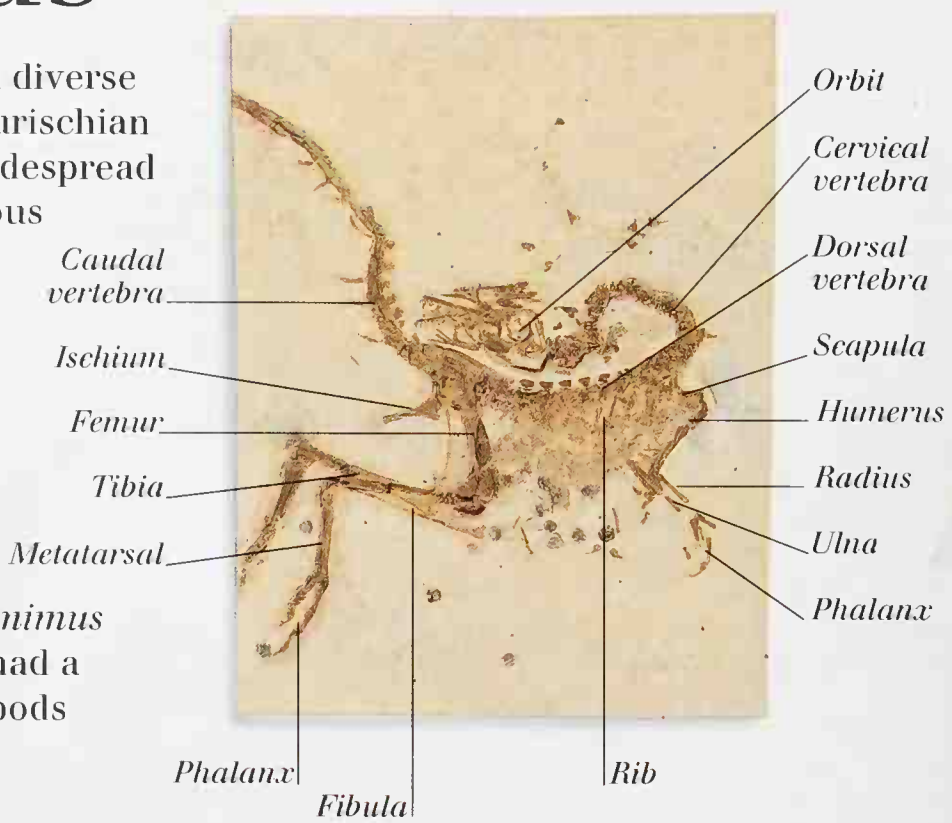
# Small theropods



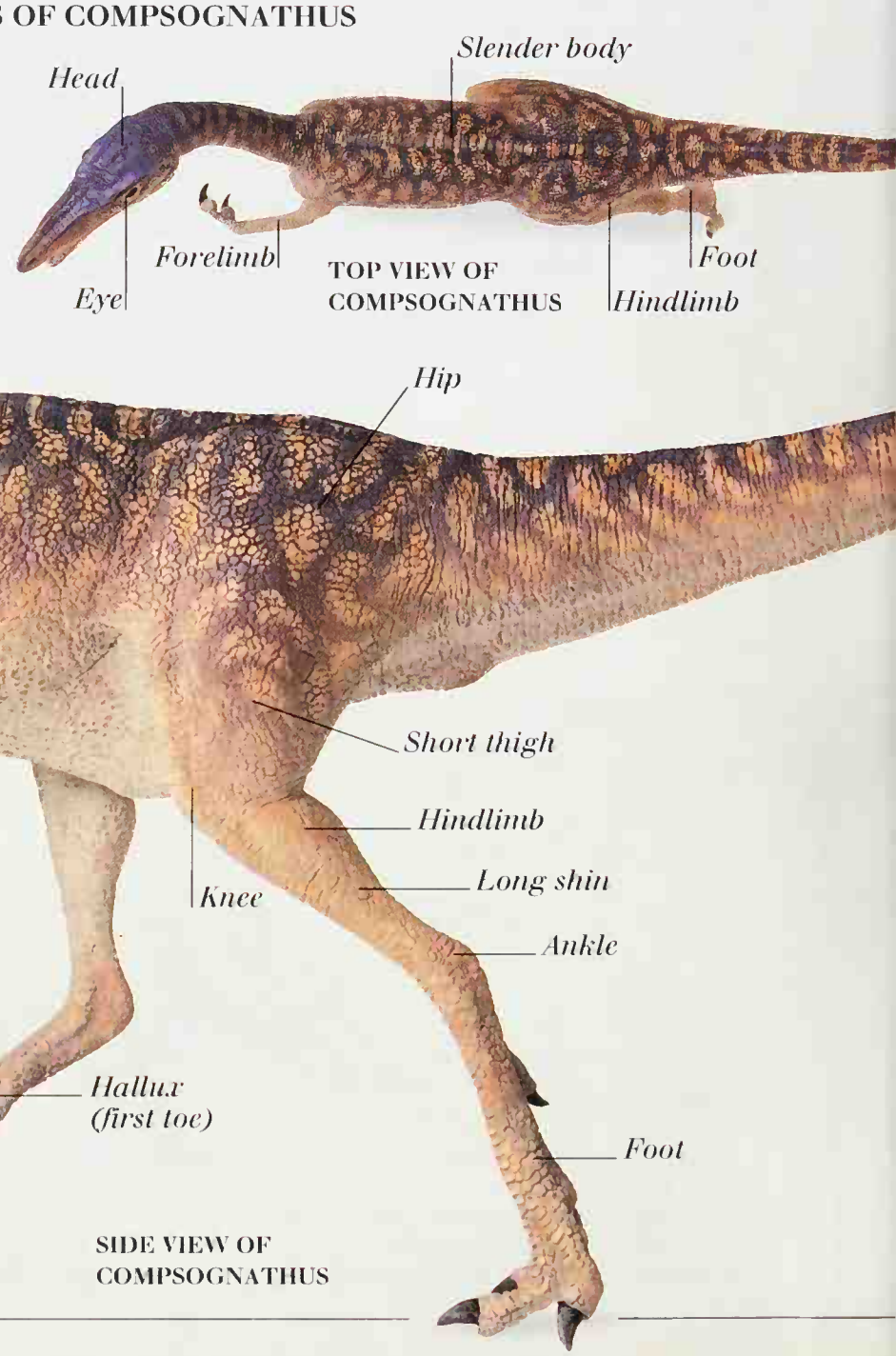
PROCOMPSOGNATHUS

SMALL THEROPODS were a diverse group of lightweight, predatory, saurischian (lizard-hipped) dinosaurs that were widespread from Late Triassic to Late Cretaceous times (231–65 million years ago). This group included some of the smallest dinosaurs known; *Compsognathus* was one of the smallest, at about 28 in (70 cm) long, and even the largest small theropod, *Coelophysis*, was only 10 ft (3 m) long. Typical small theropods – for example, *Coelophysis*, *Ornitholestes*, and *Compsognathus* – had narrow jaws with sharp teeth; long, flexible necks; long tails; and long legs that enabled them to run fast. *Avimimus* was different from other small theropods because it had a toothless beak that resembled that of toothless theropods (see pp. 18-19).

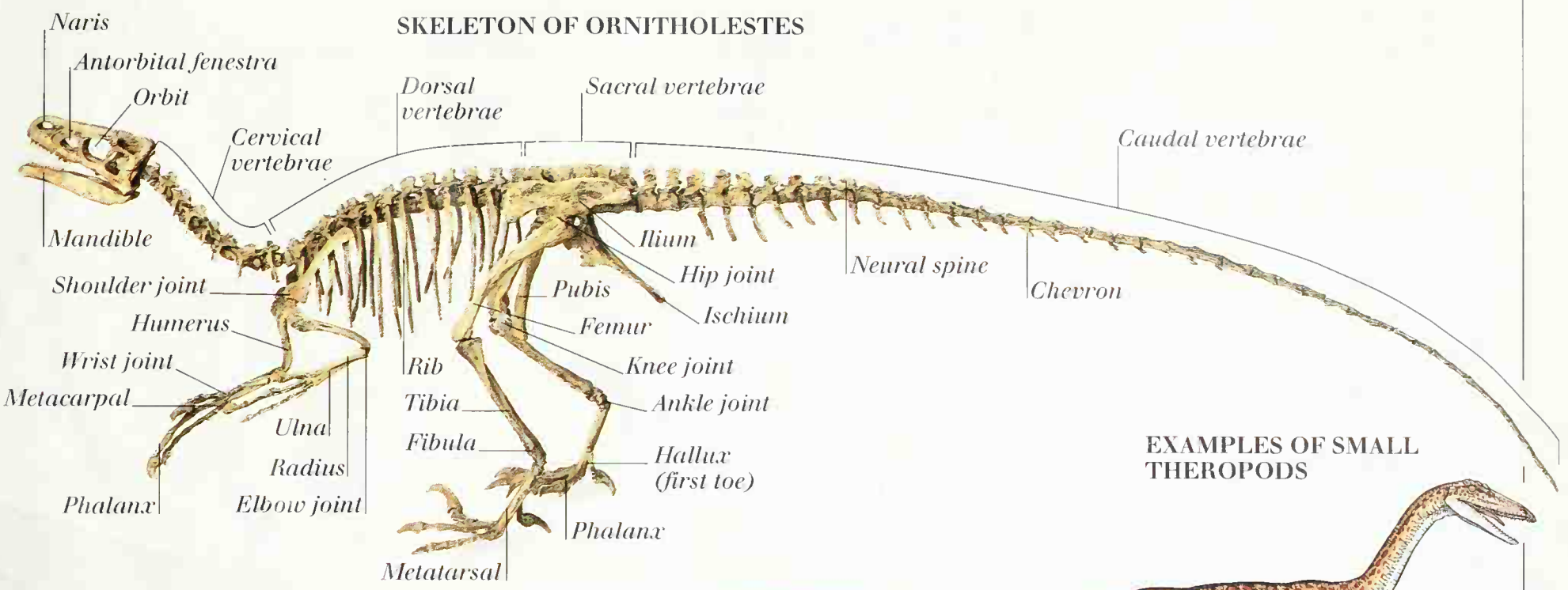
**FOSSIL SKELETON OF COMPSOGNATHUS**



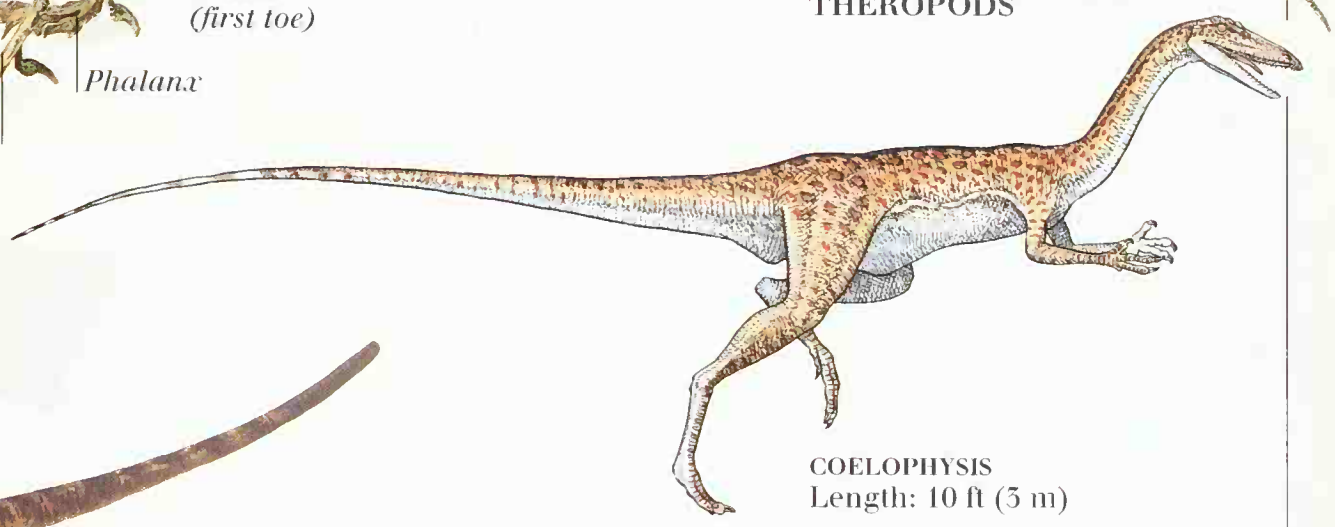

**EXTERNAL FEATURES OF COMPSOGNATHUS**



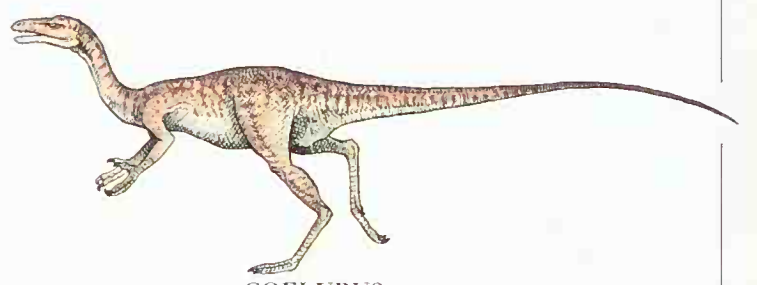
## SKELETON OF ORNITHOLESTES



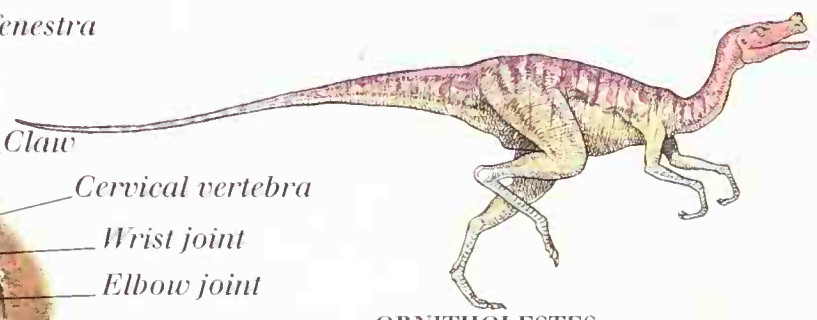

## EXAMPLES OF SMALL THEROPODS



**COELOPHYSIS**
Length: 10 ft (3 m)



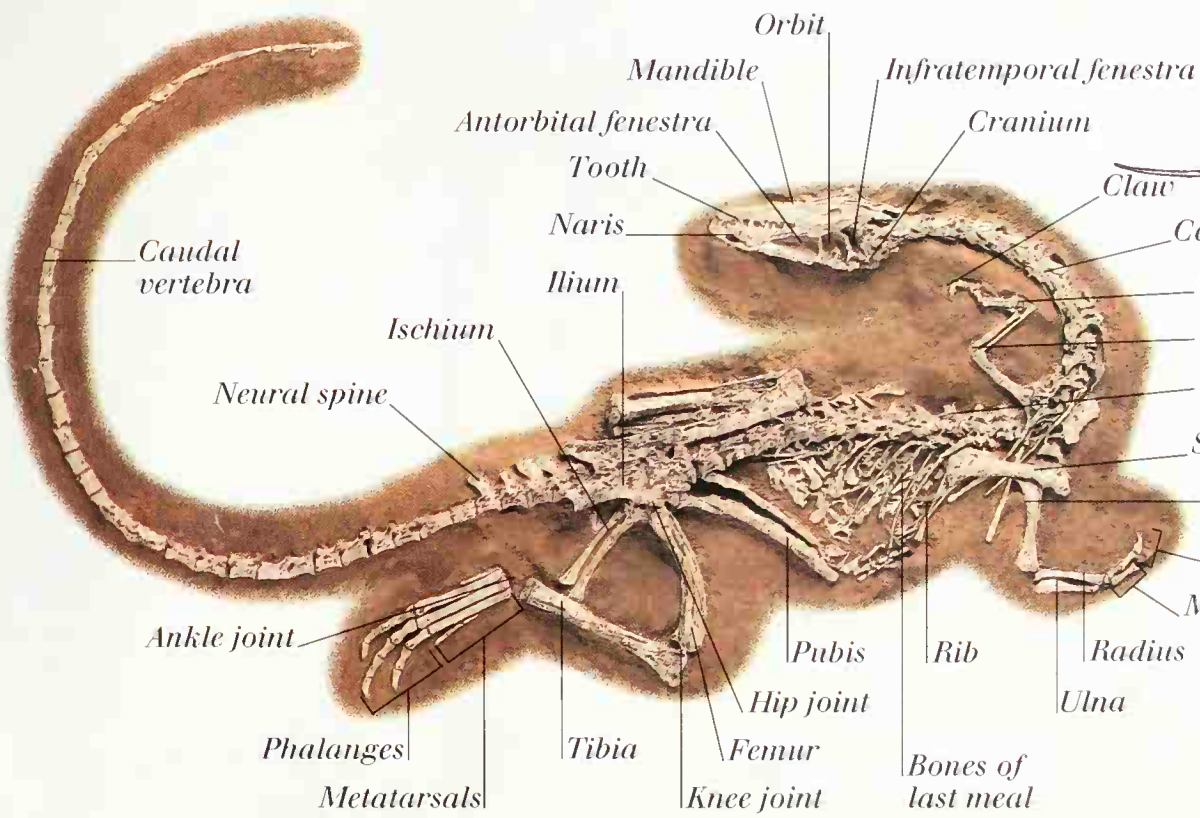
**COELURUS**
Length: 6 ft (1.8 m)



**ORNITHOLESTES**
Length: 6 ft 6 in (2 m)

**AVIMIMUS**
Length: 5 ft (1.5 m)

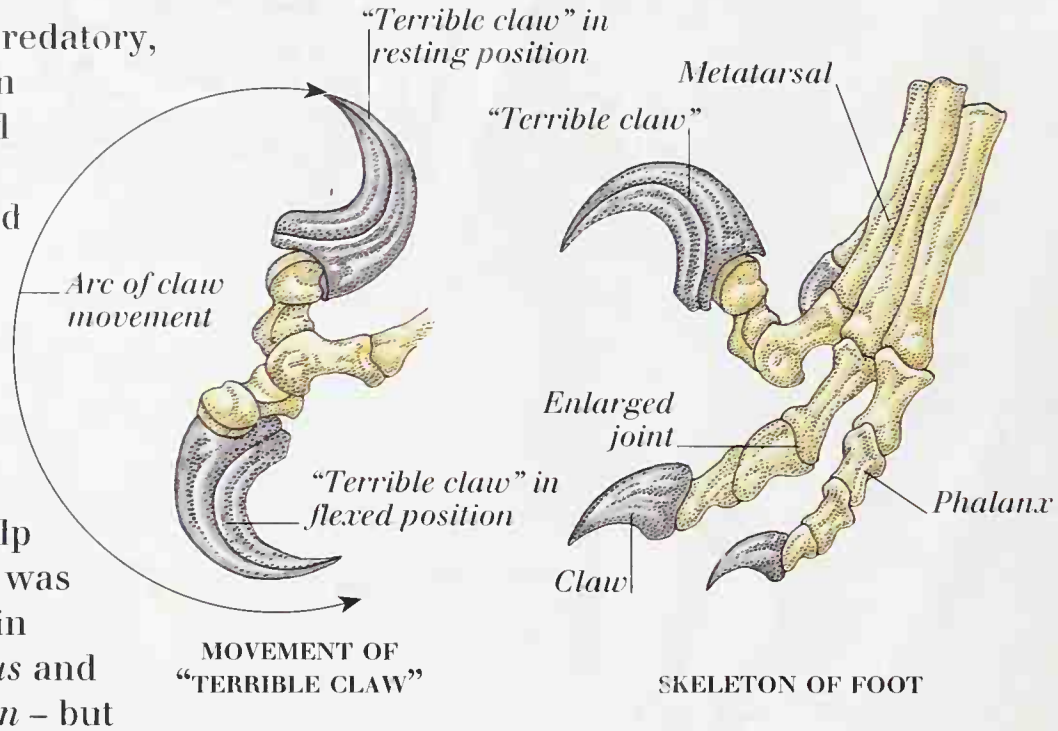
## FOSSIL SKELETON OF COELOPHYSIS



# Deinonychosaurs

DEINONYCHOSAURS WERE A GROUP of ferocious, predatory, saurischian (lizard-hipped) dinosaurs that lived in northern continents during the Cretaceous period (144–65 million years ago). The characteristic feature of these dinosaurs is a large, sickle-shaped claw on their second toe (deinonychosaur means "terrible claw lizard"). This claw flicked forward to slash prey during an attack. Deinonychosaurs were relatively small – ranging from about 6 ft (1.8 m) to 13 ft (4 m) in length – and agile, running on their powerful hindlegs and using their long, stiff tail to keep balance and also to help change direction quickly by acting as a rudder. It was thought that deinonychosaurs comprised two main subgroups – dromaeosaurids, such as *Deinonychus* and *Dromaeosaurus*, and troodontids, such as *Troodon* – but recent evidence suggests that dromaeosaurids and troodontids are not as closely related as previously believed. Dromaeosaurids had eyes at the side of the head, giving them a wide angle of vision. Their "terrible claws" were large. By hunting in packs, dromaeosaurids may have brought down prey much larger than themselves. By contrast, troodontids had smaller "terrible claws" and large, forward-facing eyes, which may have given them three-dimensional vision. Troodontids had larger brains, relative to their body size, than those of any other known dinosaur.

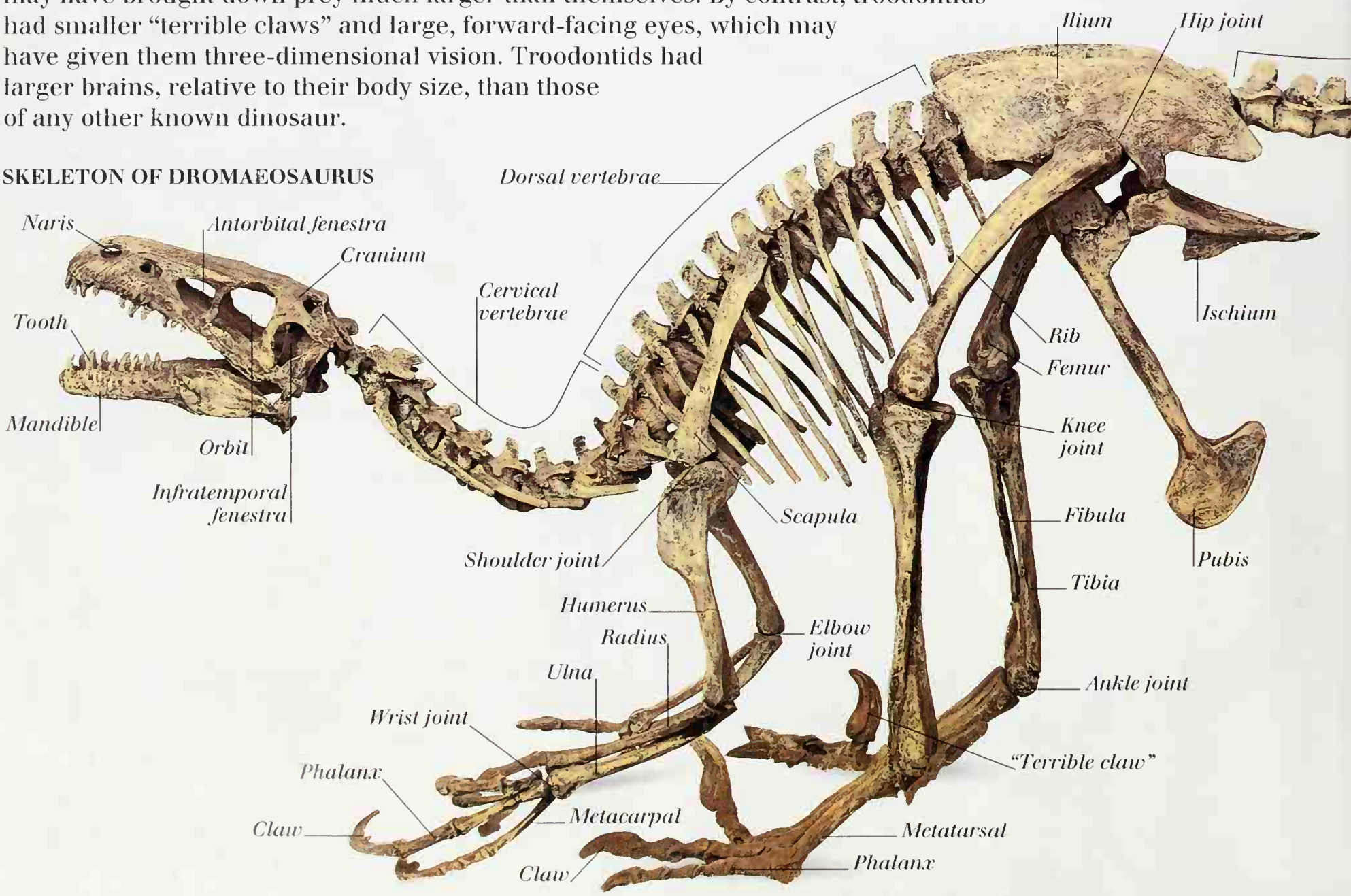
**FOOT OF DEINONYCHUS**



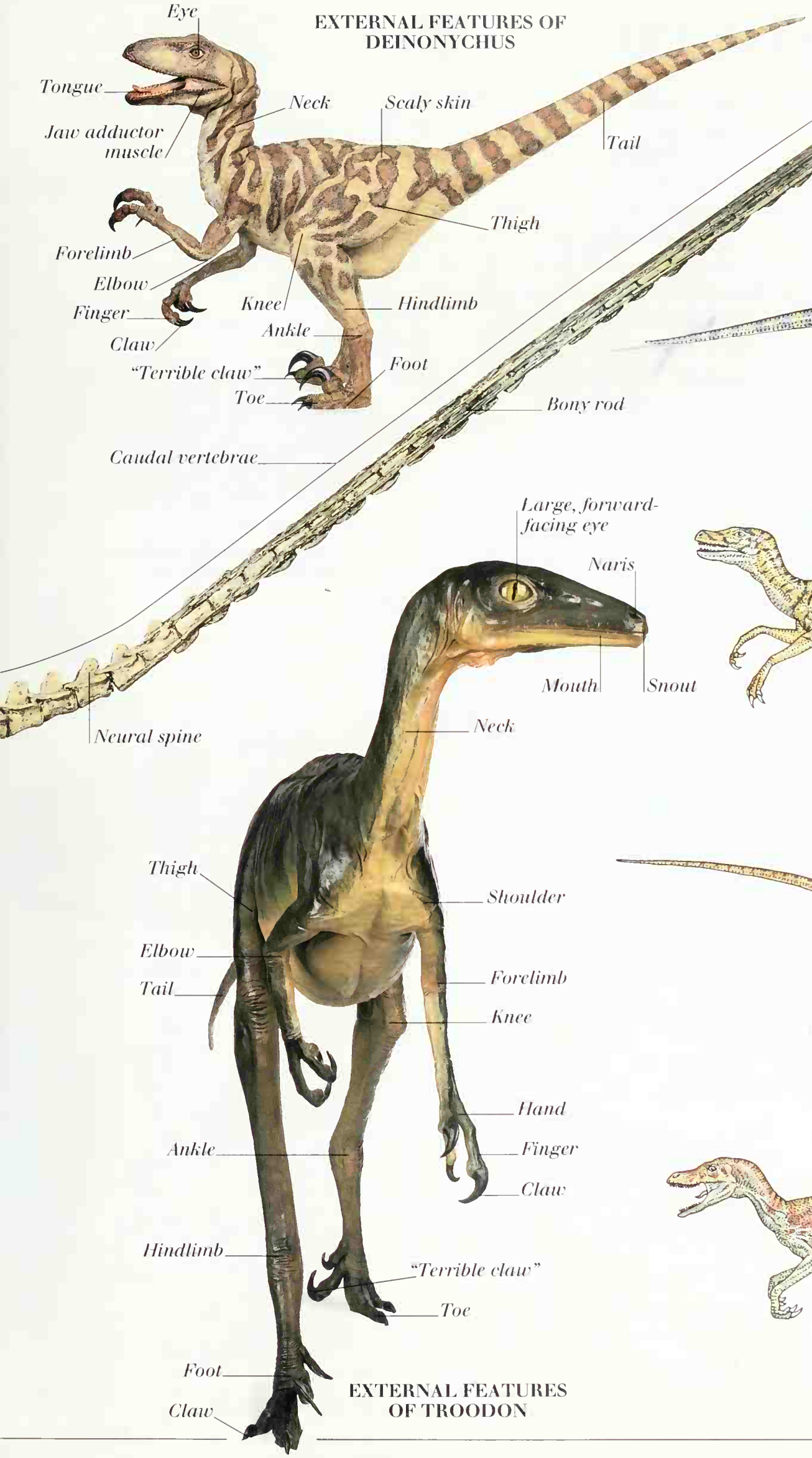

MOVEMENT OF "TERRIBLE CLAW"

SKELETON OF FOOT

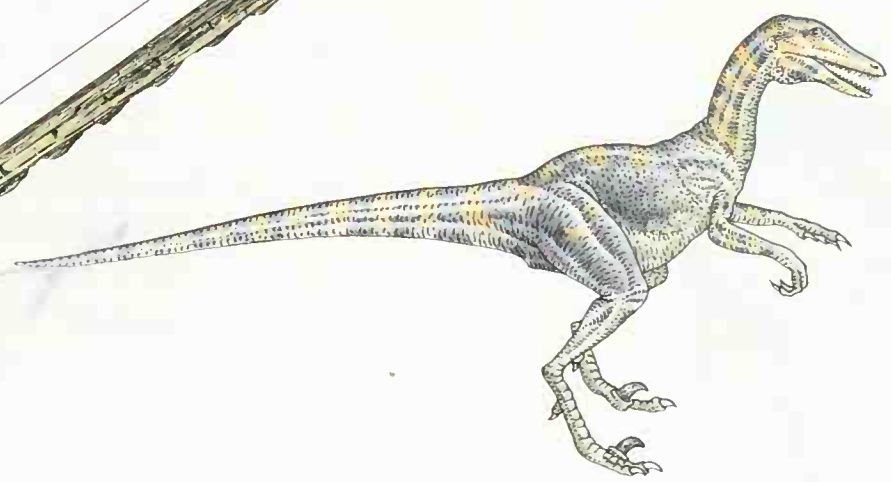
**SKELETON OF DROMAEOSAURUS**



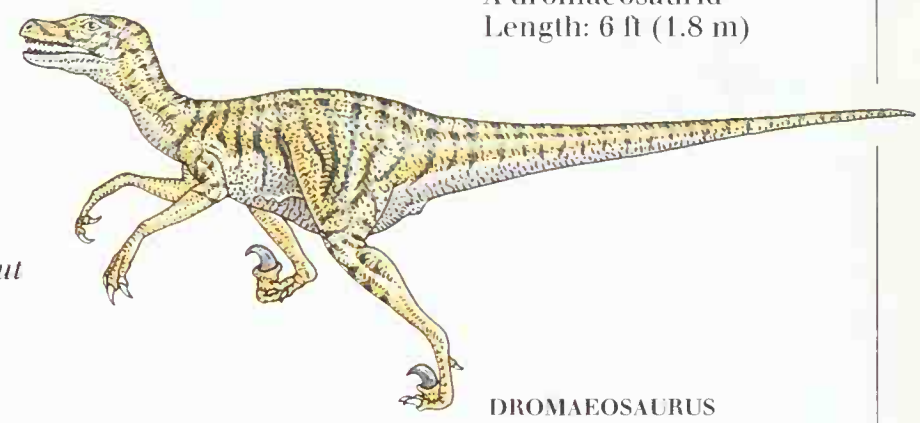
## EXTERNAL FEATURES OF DEINONYCHUS




## EXAMPLES OF DEINONYCHOSAURS



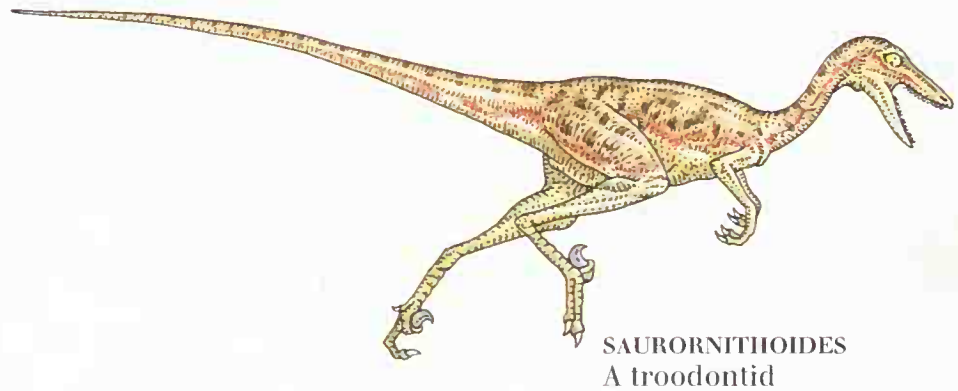
SAURORNITHOLESTES
A dromaeosaurid
Length: 6 ft (1.8 m)



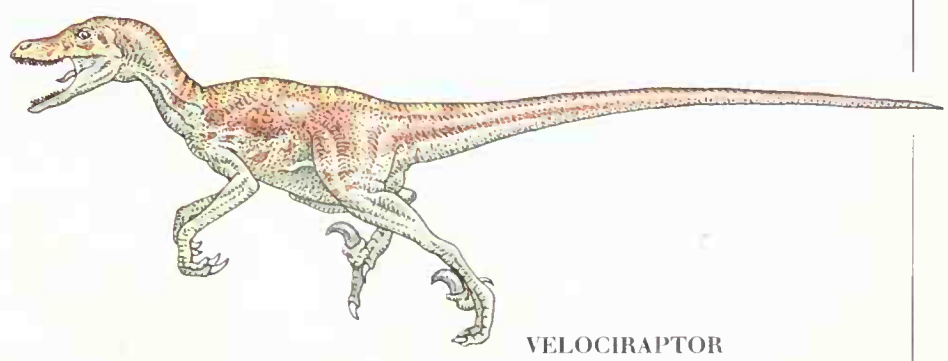

DROMAEOSAURUS
A dromaeosaurid
Length: 6 ft (1.8 m)




## EXTERNAL FEATURES OF TROODON



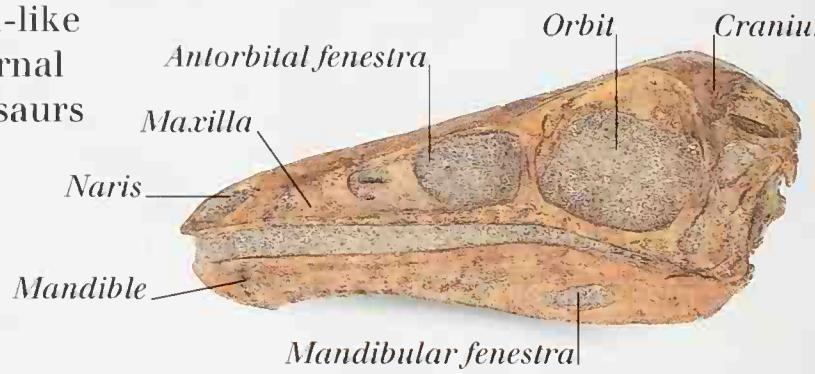
SAURORNITHOIDES
A troodontid
Length: 6 ft 6 in (2 m)



VELOCIRAPTOR
A dromaeosaurid
Length: 6 ft (1.8 m)

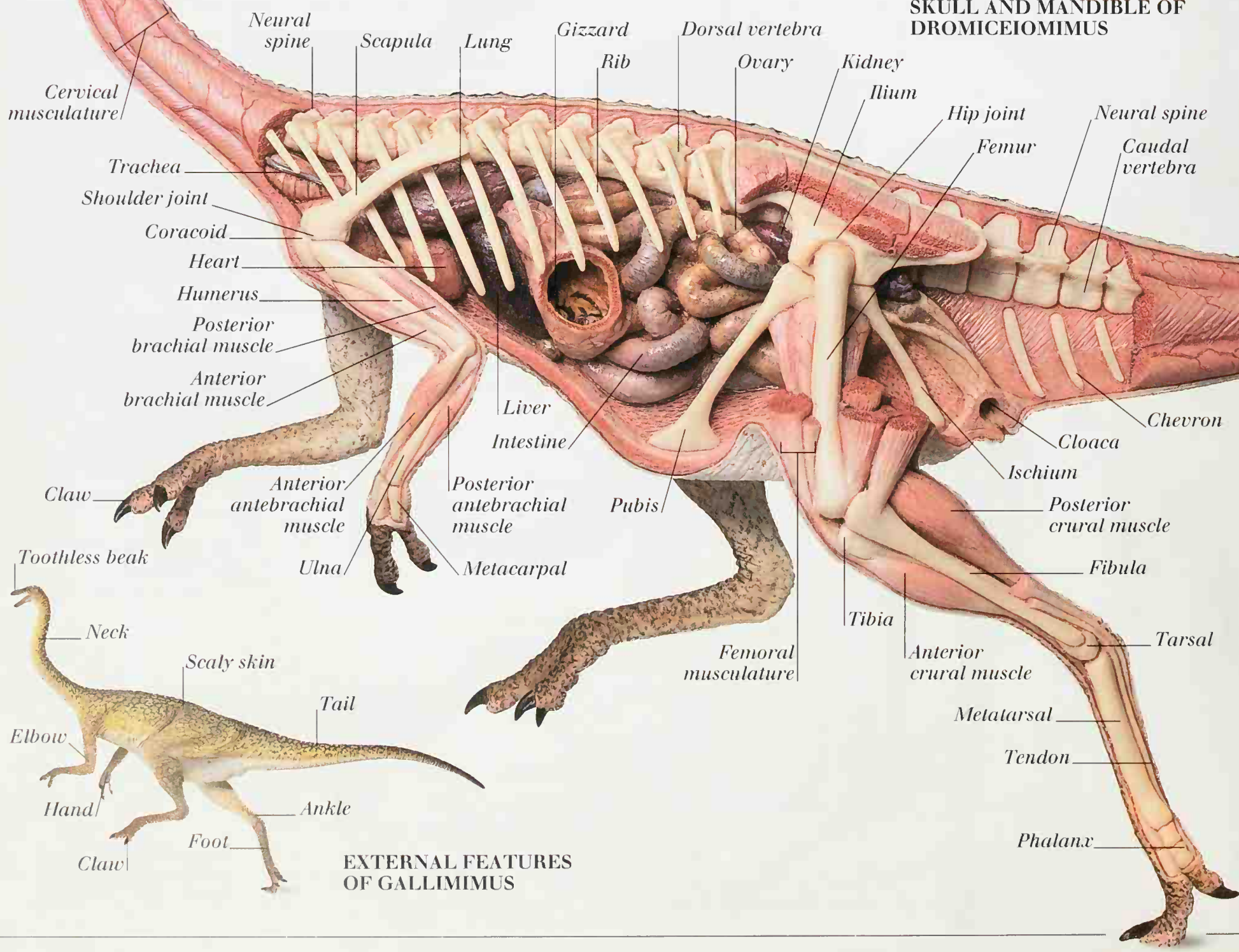
# Toothless theropods

TOOTHLESS THEROPODS COMPRISED TWO MAIN SUBGROUPS OF saurischian (lizard-hipped) dinosaur: ornithomimosaurs and oviraptorosaurs. Both groups lived during Late Cretaceous times (97.5–65 million years ago) in what are now Asia, North America, and Africa. They had toothless beaks, in contrast to the small theropods (see pp. 14-15), which had jaws containing small, sharp teeth. Ornithomimosaurs (meaning "bird-mimic lizards"), such as *Gallimimus*, *Ornithomimus*, *Struthiomimus*, and *Dromiceiomimus*, had some features in common with the modern ostrich: a small head with a long, narrow beak, a long neck, and powerful hindlimbs. Oviraptorosaurs (meaning "egg-plundering lizards"), such as *Oviraptor* (see p. 32), also had ostrich-like features, but their beaks were short. The internal anatomy of ornithomimosaurs and oviraptorosaurs is thought to have resembled that of modern birds, with a gizzard (muscular stomach) for grinding up food.




SKULL AND MANDIBLE OF DROMICEIOMIMUS

INTERNAL ANATOMY OF FEMALE GALLIMIMUS





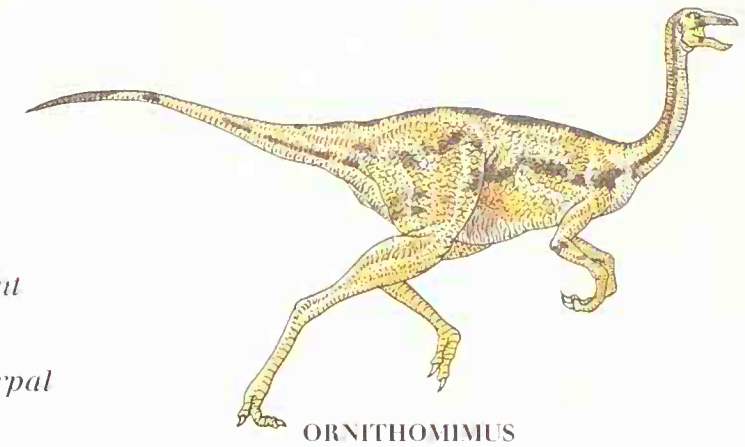


EXTERNAL FEATURES OF GALLIMIMUS

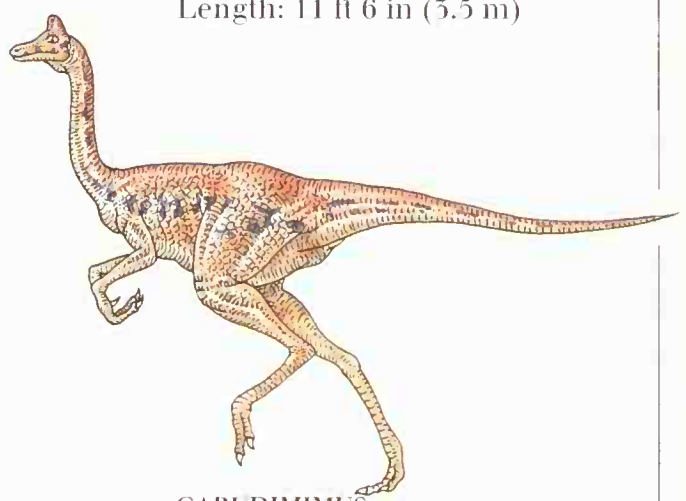
Caudal vertebrae
Ilium
Hip joint
Dorsal vertebrae
Cervical vertebrae
Cranium
Naris
Mandible
Orbit
Scapula
Humerus
Wrist joint
Metacarpal
Phalanx
Chevron
Neural spine
Rib
Ischium
Ulna
Femur
Pubis
Radius
Knee joint
Tibia
Ankle joint
Metatarsals
Phalanges

**SKELETON OF ORNITHOMIMUS**

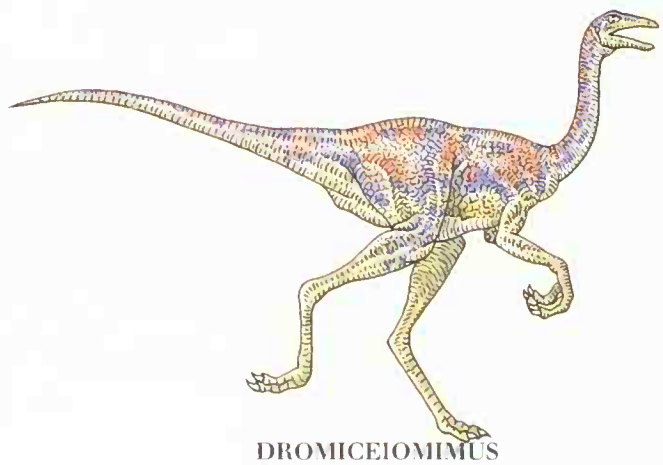
**EXAMPLES OF ORNITHOMIMOSAURS**



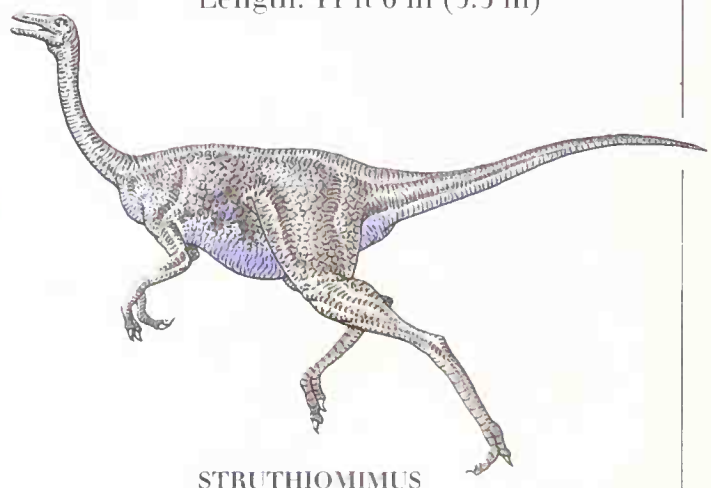
**ORNITHOMIMUS**
Length: 11 ft 6 in (3.5 m)



**GARUDIMIMUS**
Length: 11 ft 6 in (3.5 m)



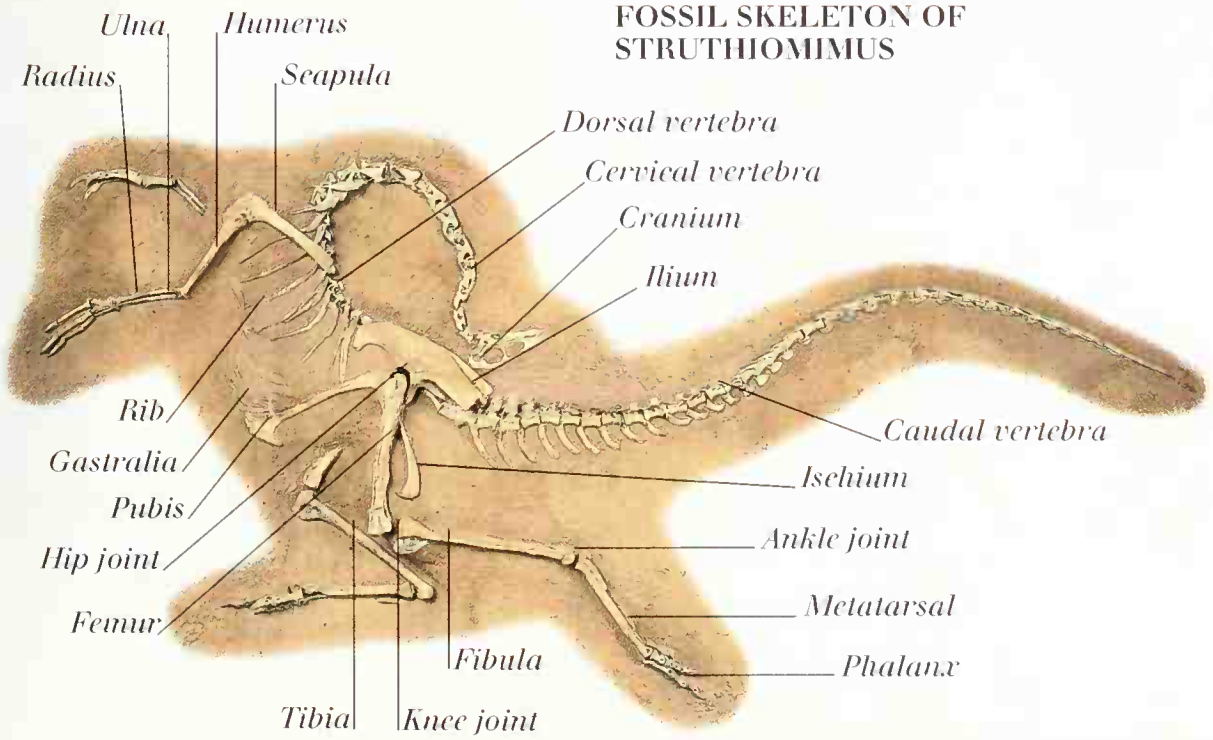
**DROMICEIOMIMUS**
Length: 11 ft 6 in (3.5 m)



**STRUTHIOMIMUS**
Length: 11 ft 6 in (3.5 m)

Lateral caudal musculature
Scaly skin
Tail

**FOSSIL SKELETON OF STRUTHIOMIMUS**



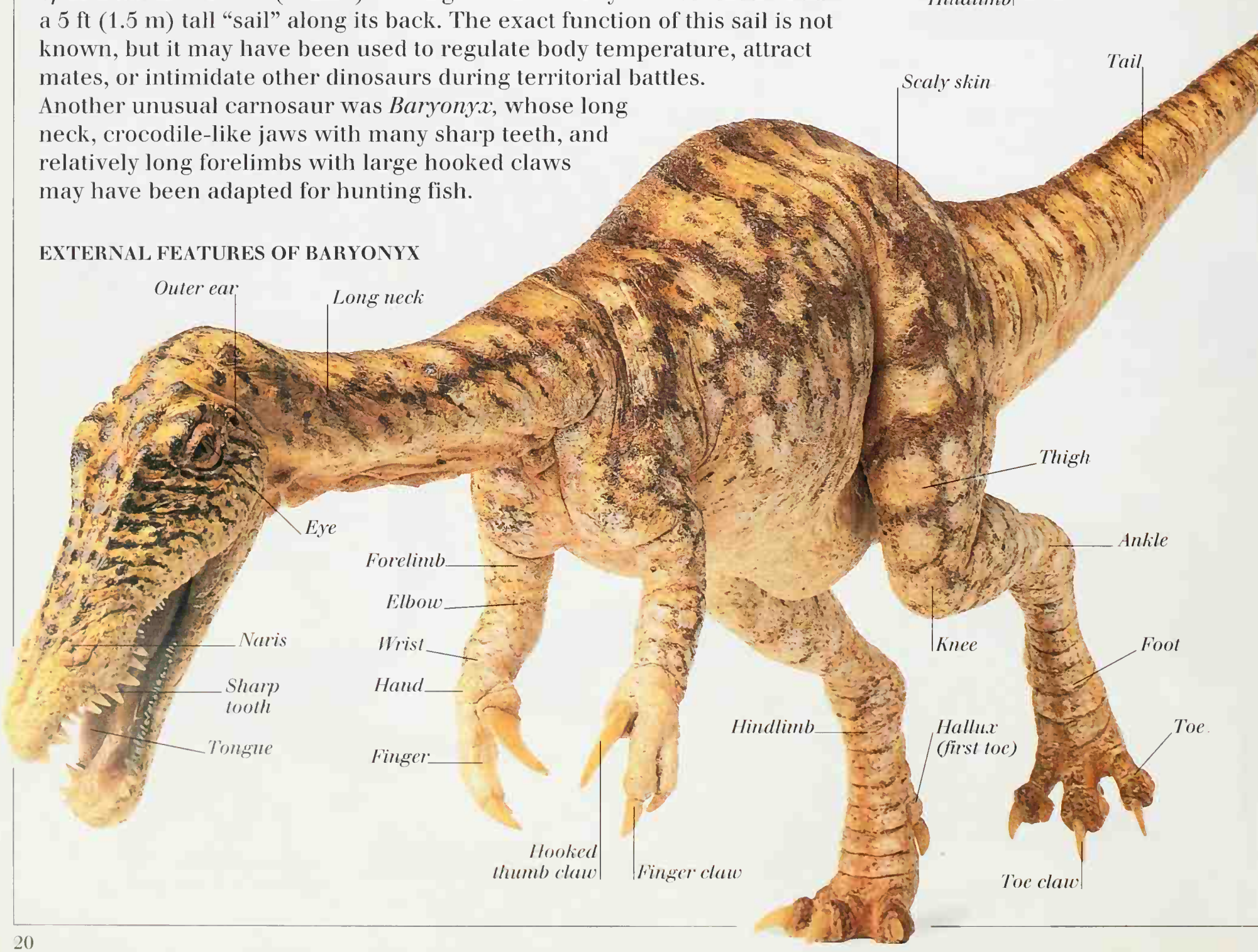
# Carnosaurs 1

BARYONYX CLAW

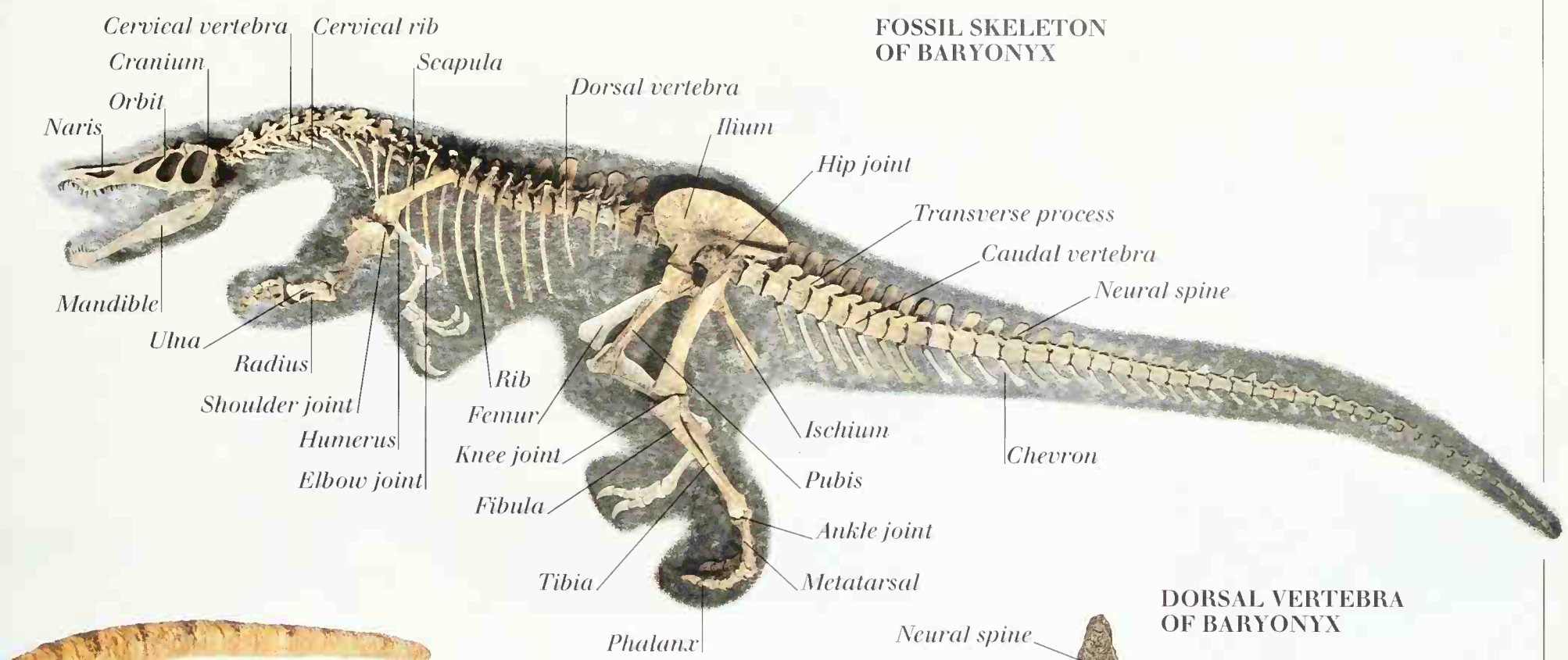
CARNOSAURS IS A TERM OFTEN USED loosely for the Carnosauria and other large flesh-eating, saurischian (lizard-hipped) dinosaurs, such as *Carnotaurus* (a large ceratosaur). Carnosaurs ranged in size from 20 ft (6.1 m) to 50 ft (15.2 m) in length, and weighed up to about 6.3 tons. As a group, carnosaurs were very successful; they lived from Early Jurassic to Late Cretaceous times (208–65 million years ago) and their fossils have been discovered throughout the world. Typical carnosaurs, such as *Tyrannosaurus* and *Allosaurus*, had large heads; short, muscular necks; powerful hind legs; and stiff, heavy tails to aid balance. They probably hunted herbivores (plant-eaters) and were the most formidable of all predatory dinosaurs, with jaws that could have swallowed a human, and curved, serrated teeth up to 7 in (18 cm) long for ripping flesh from their prey. Some carnosaurs had unusual features; for example, *Spinosaurus* – at 50 ft (15.2 m) the largest carnosaur yet discovered – had a 5 ft (1.5 m) tall "sail" along its back. The exact function of this sail is not known, but it may have been used to regulate body temperature, attract mates, or intimidate other dinosaurs during territorial battles. Another unusual carnosaur was *Baryonyx,* whose long neck, crocodile-like jaws with many sharp teeth, and relatively long forelimbs with large hooked claws may have been adapted for hunting fish.

**MODEL OF BARYONYX IN DEATH POSITION**

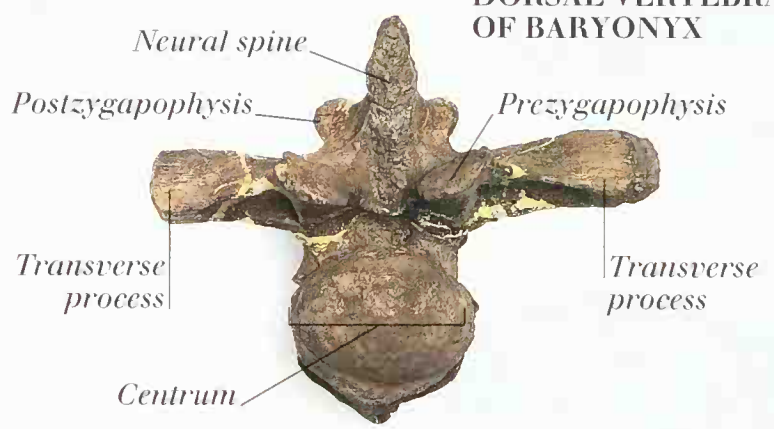
**EXTERNAL FEATURES OF BARYONYX**



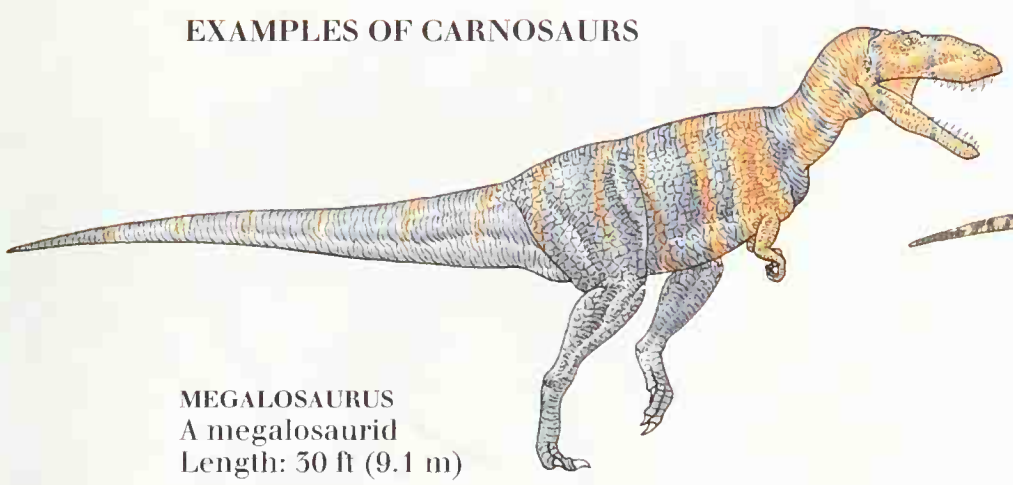
## FOSSIL SKELETON OF BARYONYX



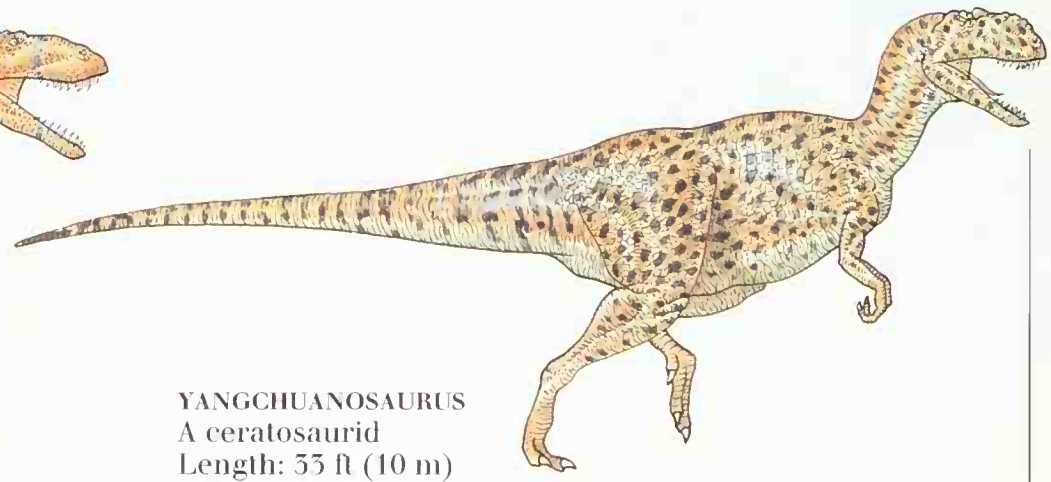

## DORSAL VERTEBRA OF BARYONYX



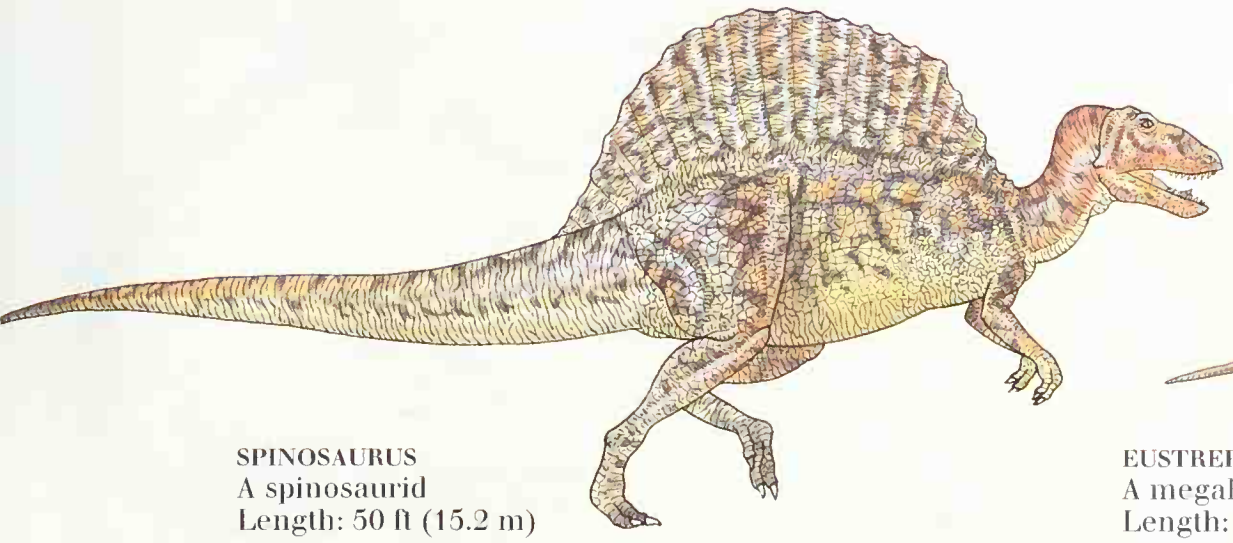

## EXAMPLES OF CARNOSAURS



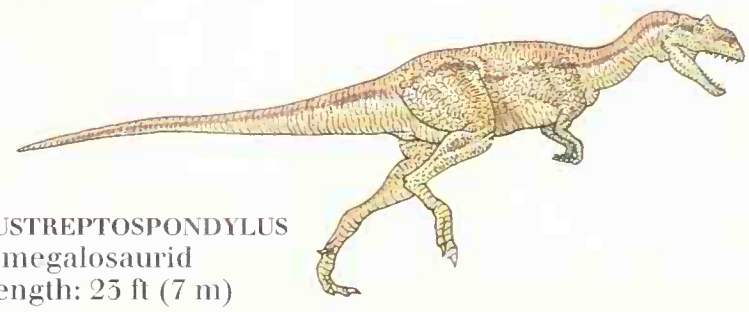
MEGALOSAURUS
A megalosaurid
Length: 30 ft (9.1 m)



YANGCHUANOSAURUS
A ceratosaurid
Length: 33 ft (10 m)



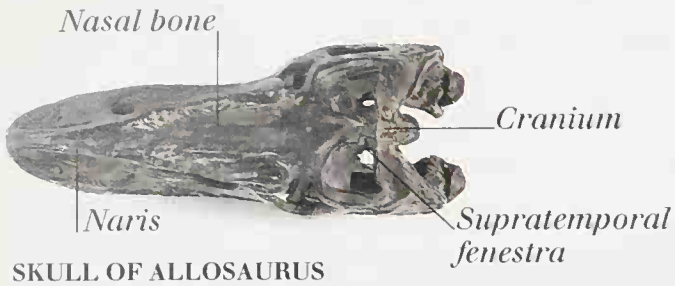
SPINOSAURUS
A spinosaurid
Length: 50 ft (15.2 m)



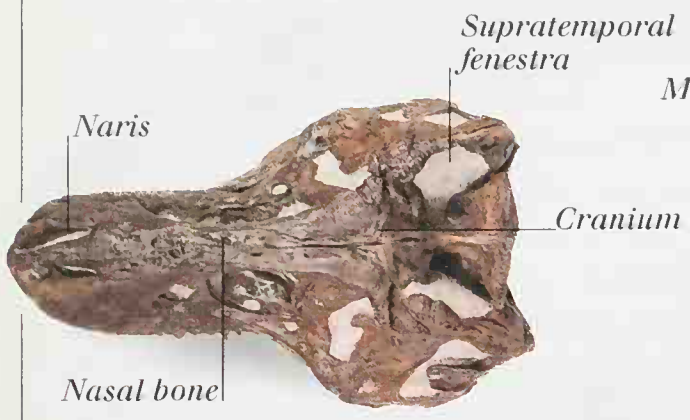
EUSTREPTOSPONDYLUS
A megalosaurid
Length: 23 ft (7 m)

# Carnosaurs 2

## TOP VIEW OF CARNOSAUR SKULLS

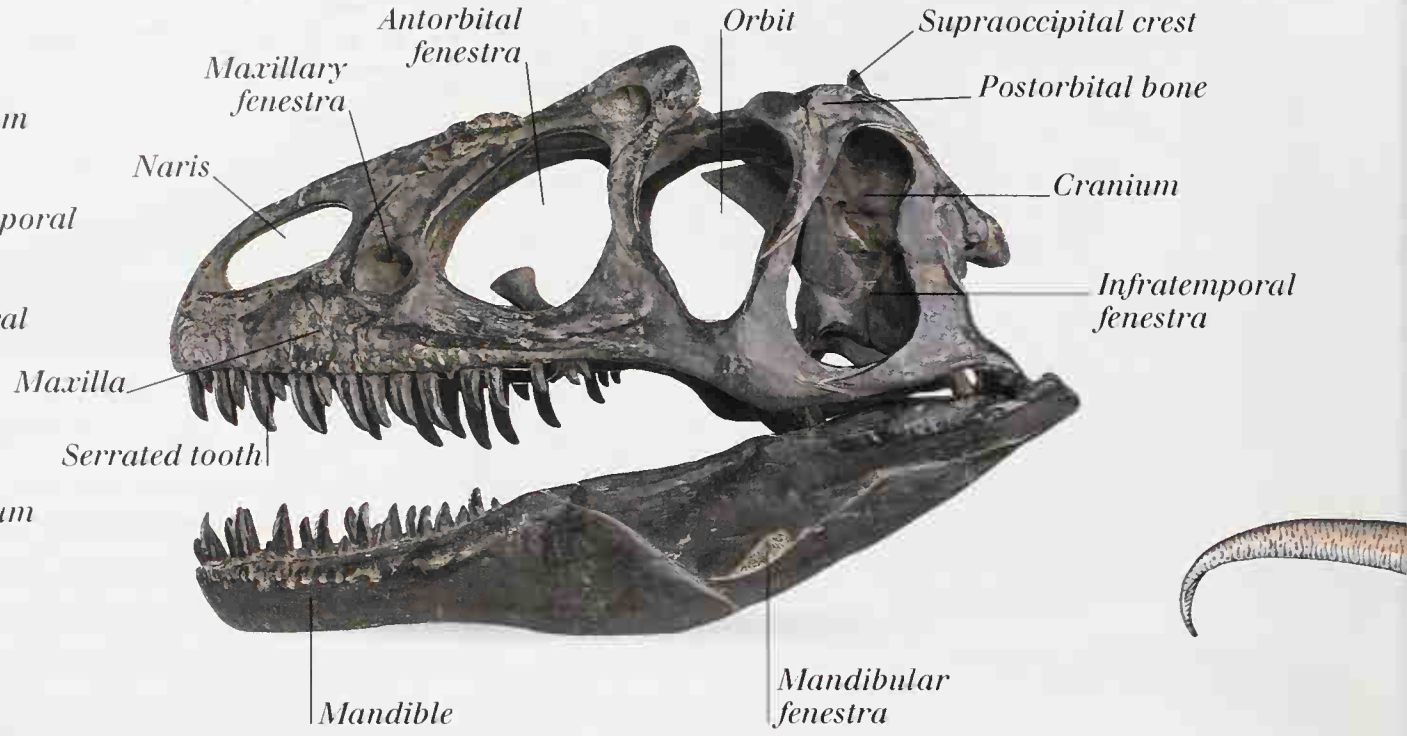



SKULL OF ALLOSAURUS



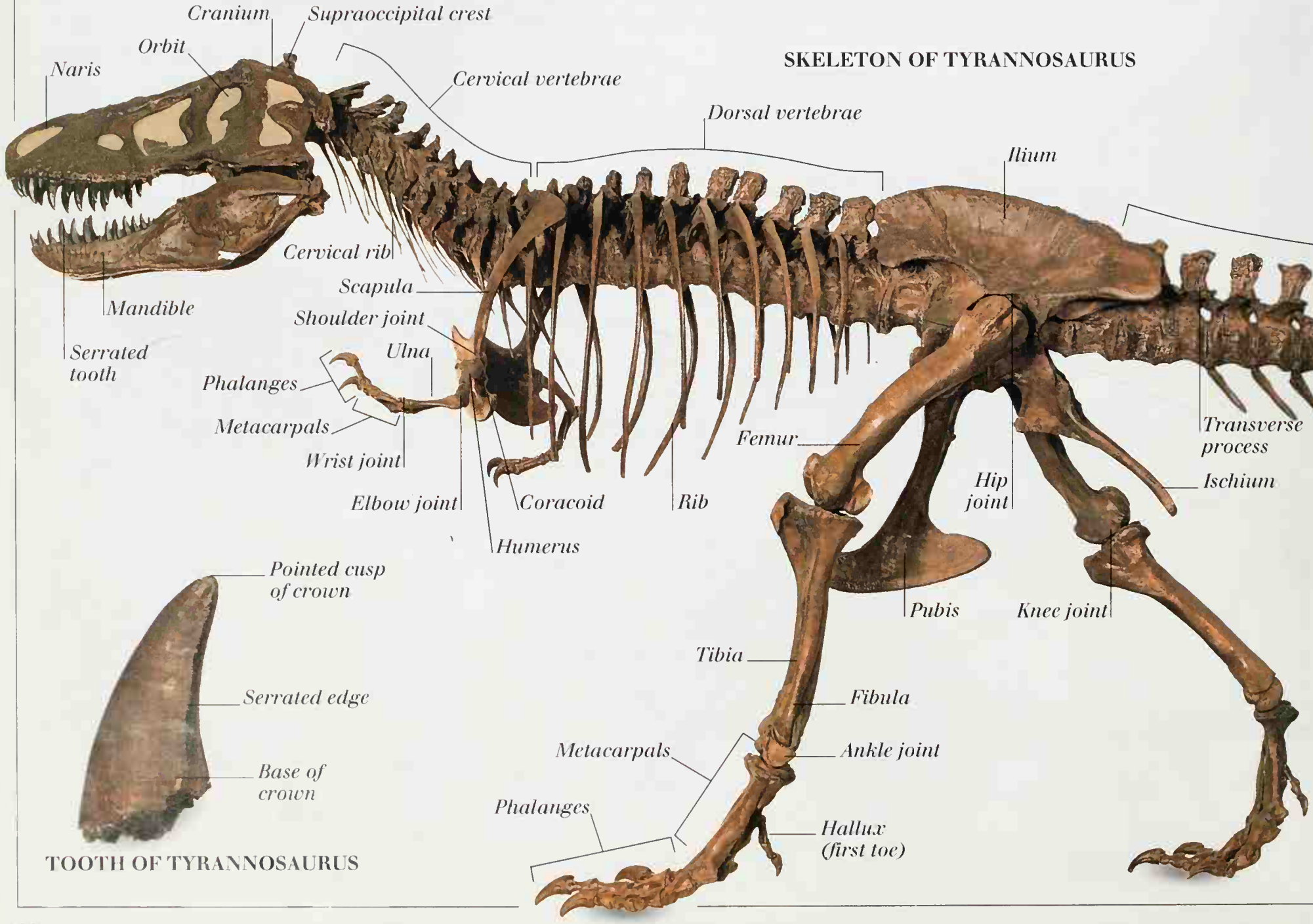

SKULL OF TYRANNOSAURUS

## SKULL AND MANDIBLE OF ALLOSAURUS






## SKELETON OF TYRANNOSAURUS

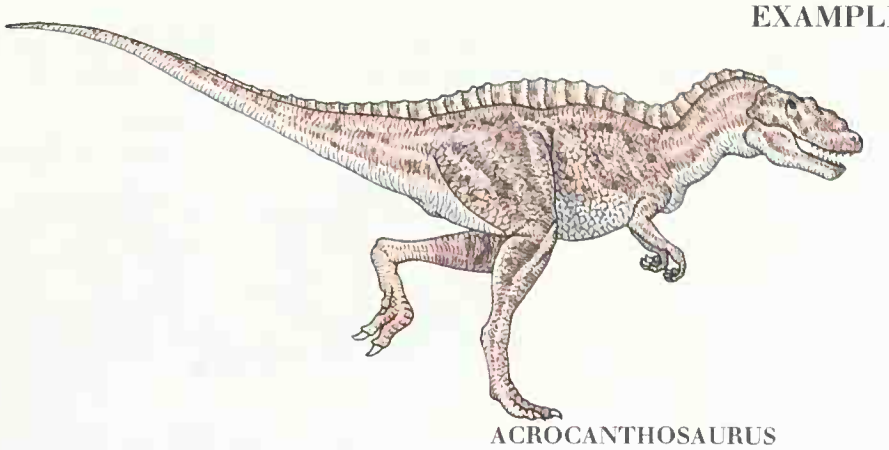




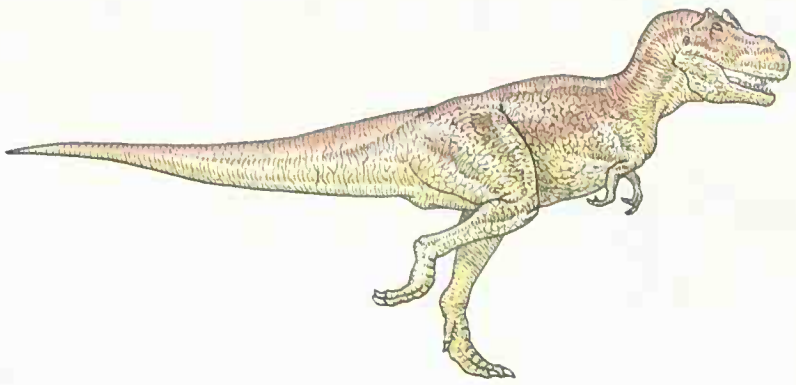


TOOTH OF TYRANNOSAURUS

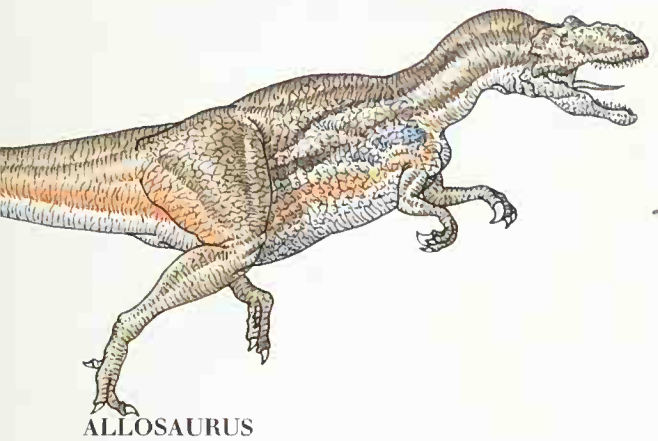
## EXAMPLES OF CARNOSAURS



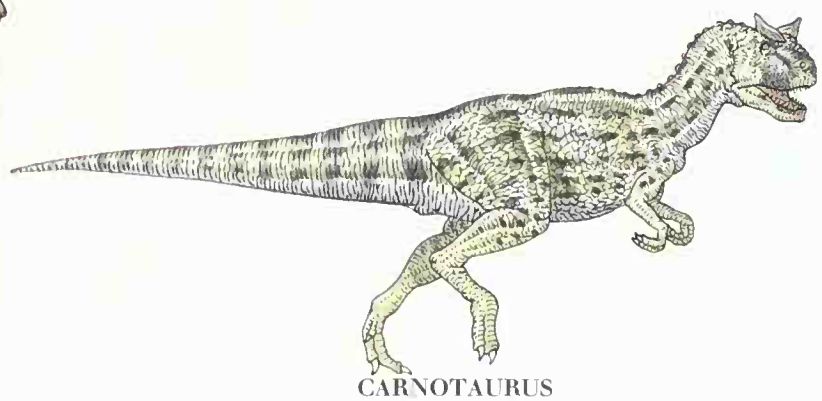
ACROCANTHOSAURUS
An allosaurid
Length: 40 ft (12.2 m)



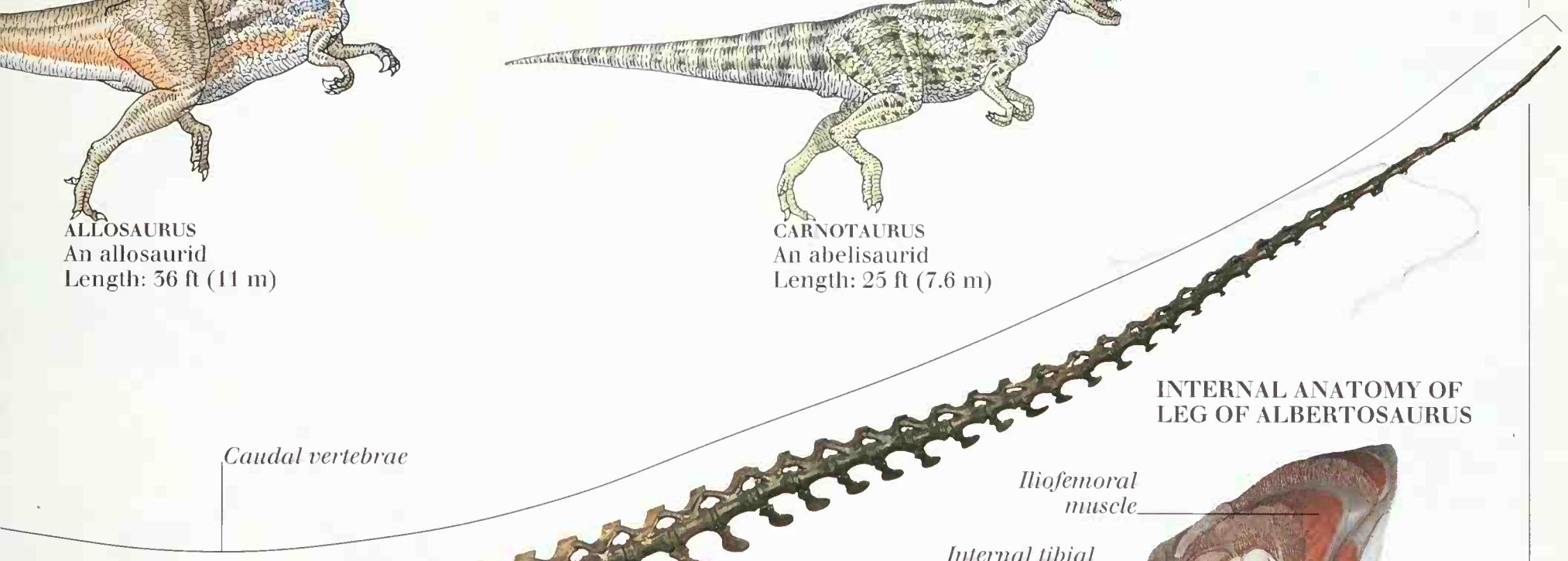
TARBOSAURUS
A tyrannosaurid
Length: 20–33 ft (6.1–10 m)

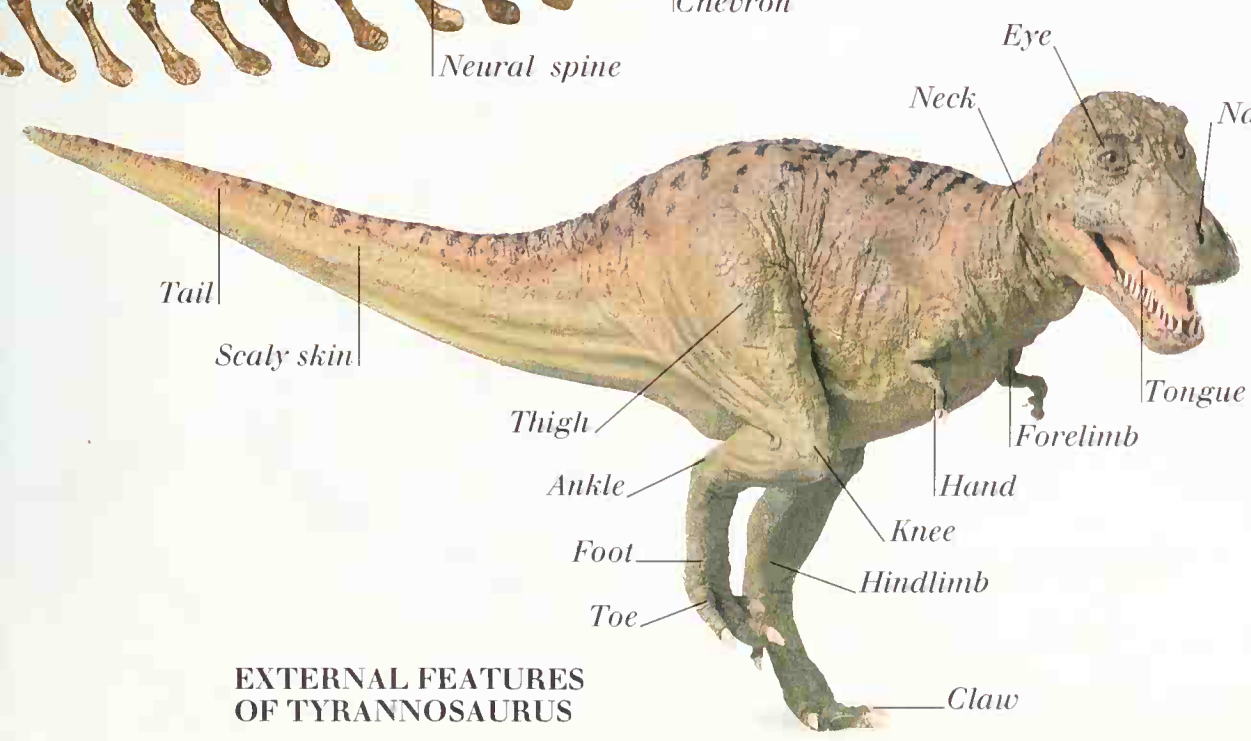


ALLOSAURUS
An allosaurid
Length: 36 ft (11 m)



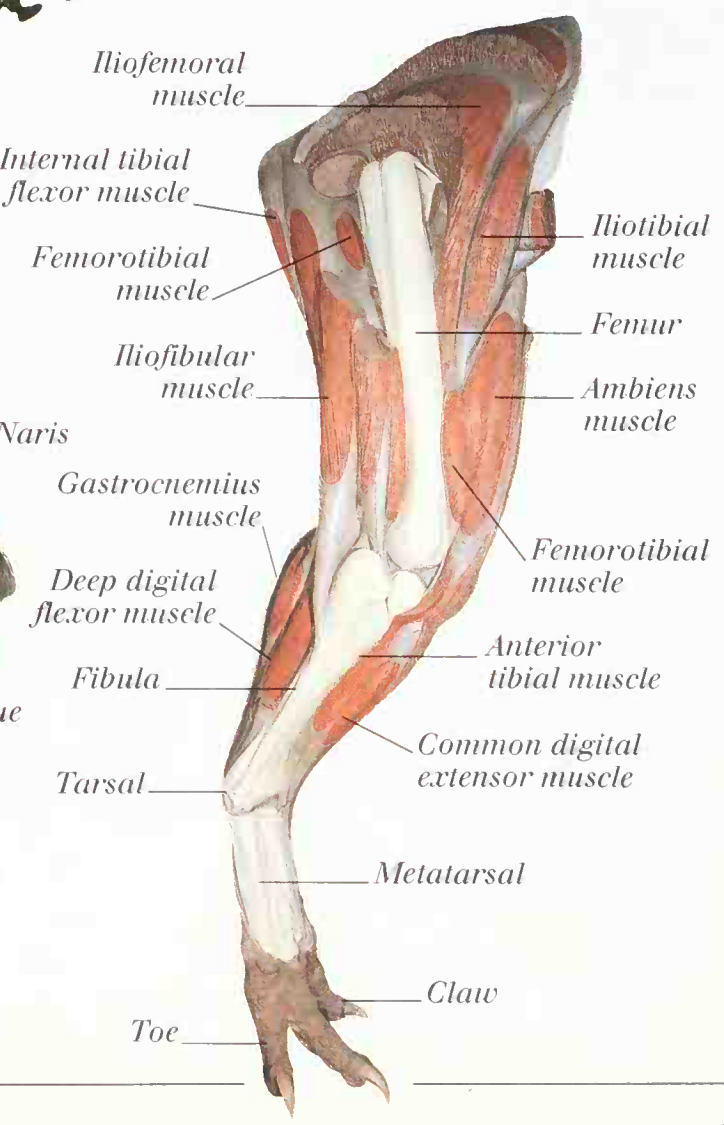
CARNOTAURUS
An abelisaurid
Length: 25 ft (7.6 m)



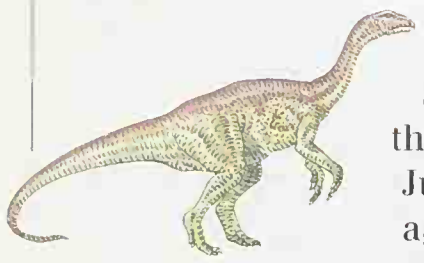




EXTERNAL FEATURES
OF TYRANNOSAURUS

## INTERNAL ANATOMY OF LEG OF ALBERTOSAURUS



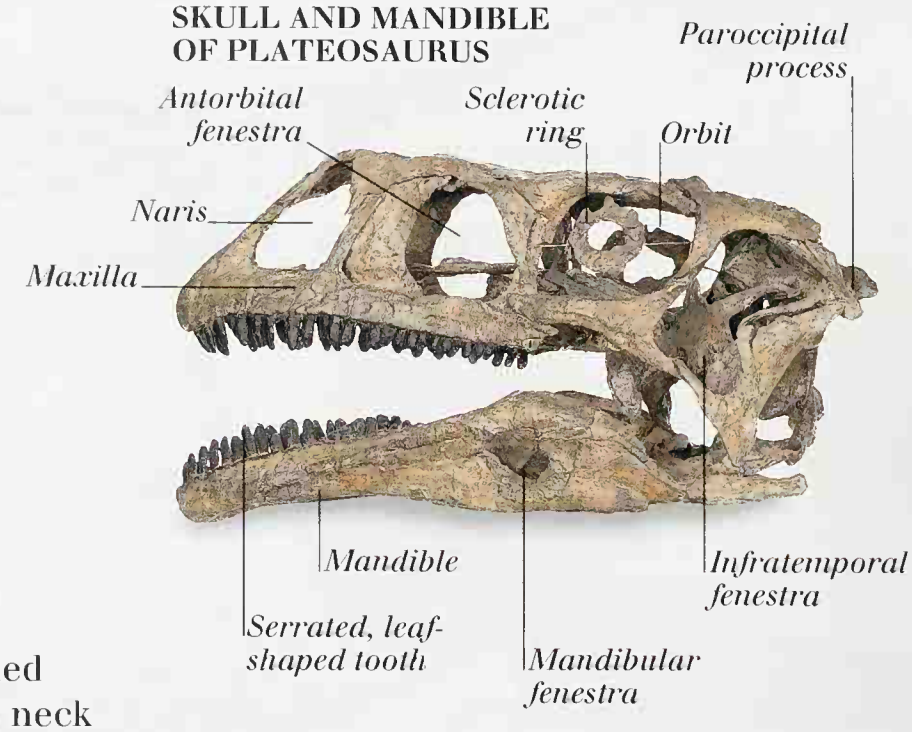
# Prosauropods



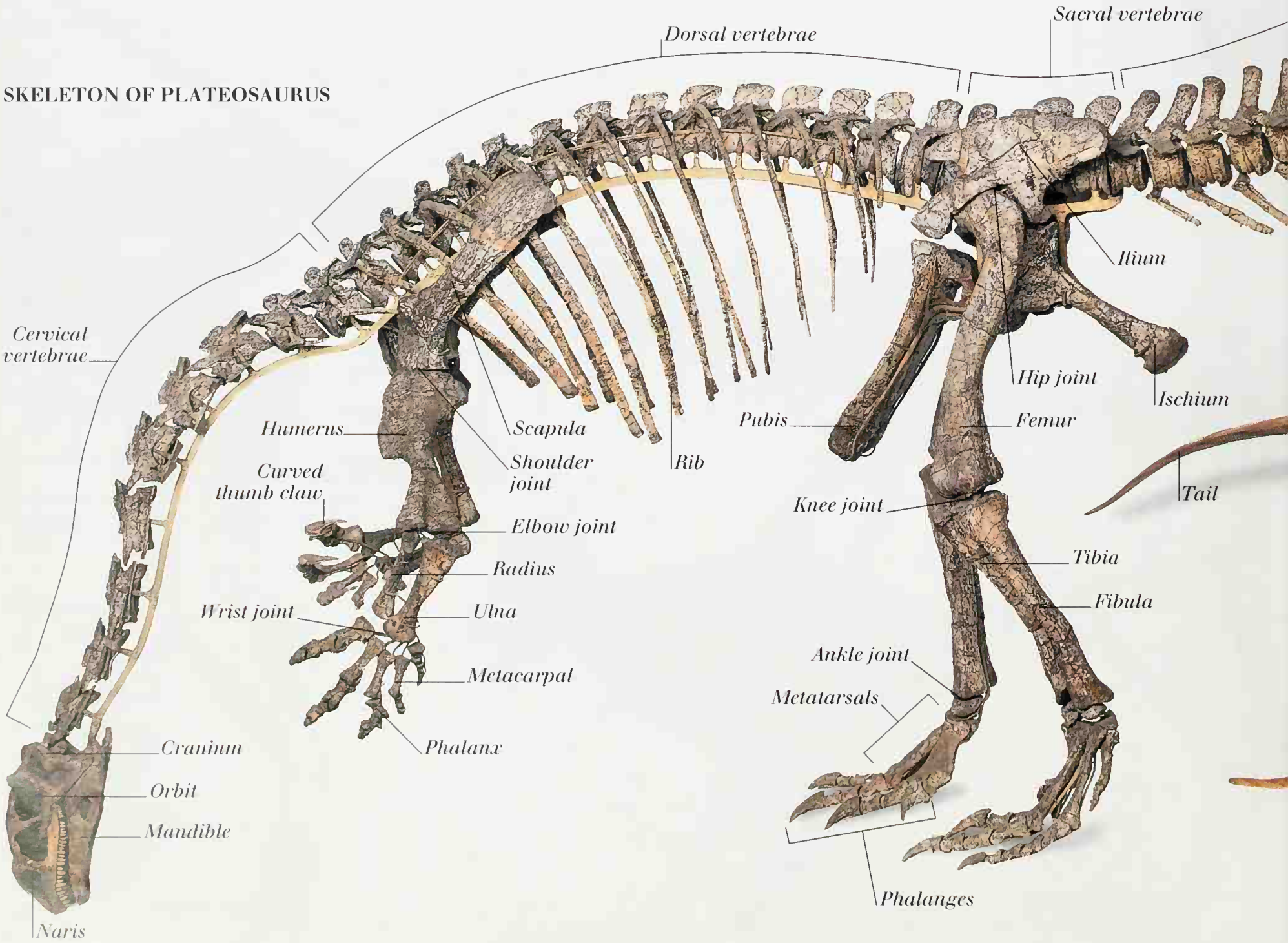
THECODONTOSAURUS

PROSAUROPODS WERE A group of saurischian (lizard-hipped) dinosaurs that lived from Late Triassic to Early Jurassic times (231–188 million years ago); they were distributed throughout the world. They are thought to have been the first large herbivorous (plant-eating) dinosaurs and may have had the same ancestors as sauropods (see pp. 26-29). Prosauropods varied considerably in size: *Anchisaurus* was one of the smaller prosauropods, at about 8 ft (2.4 m) long, and *Melanorosaurus* was one of the larger, at approximately 40 ft (12.2 m) long. Typical features of prosauropods included a small head containing leaf-shaped teeth, a relatively long neck and tail, and hindlimbs that were longer than the forelimbs; all known prosauropods had large, curved thumb claws.

**SKULL AND MANDIBLE OF PLATEOSAURUS**

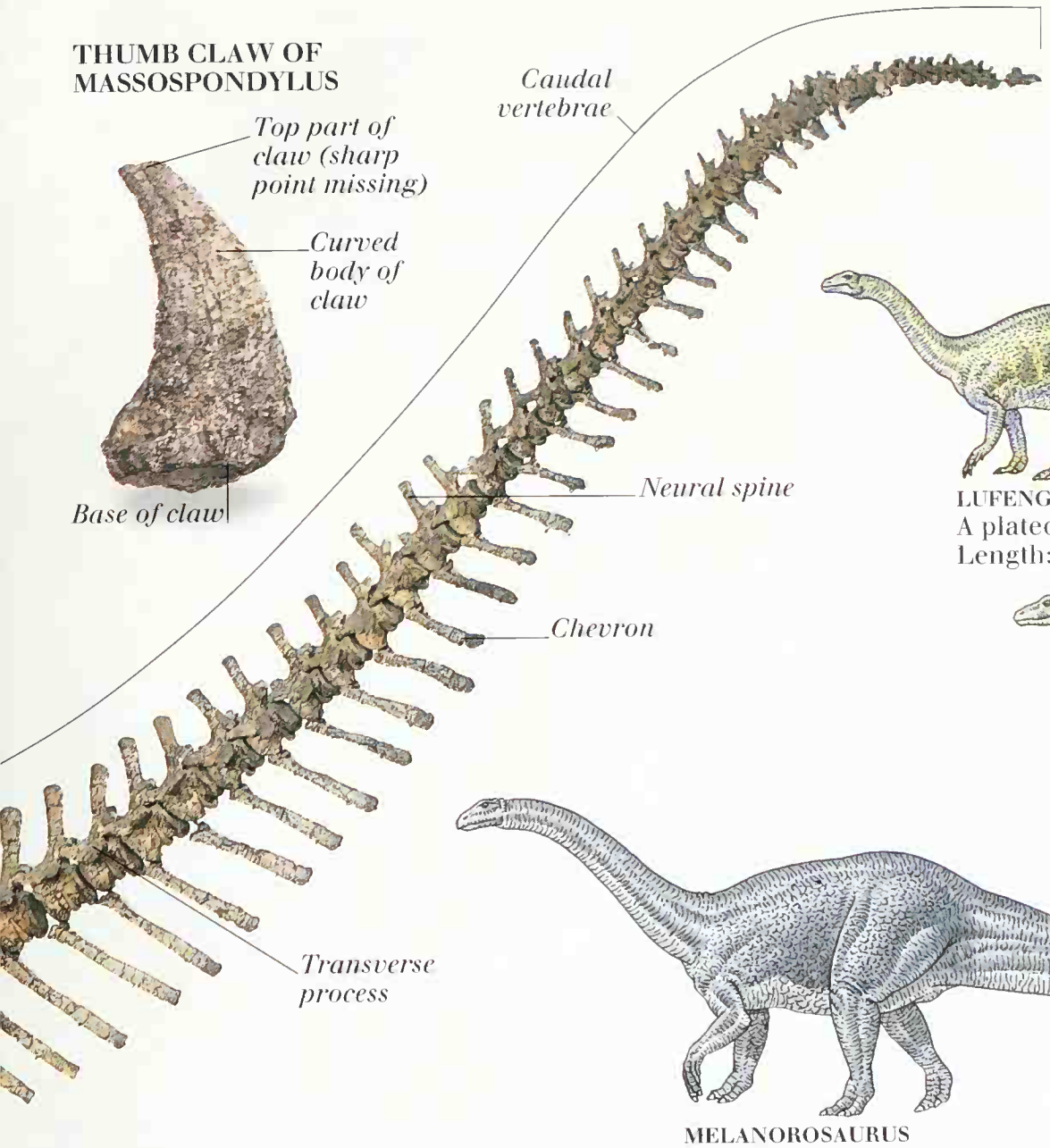



**SKELETON OF PLATEOSAURUS**

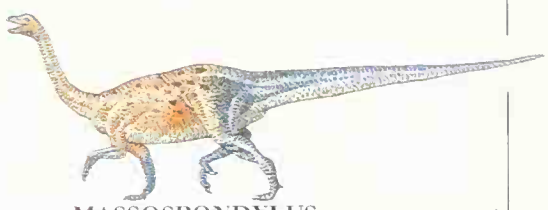


## THUMB CLAW OF MASSOSPONDYLUS

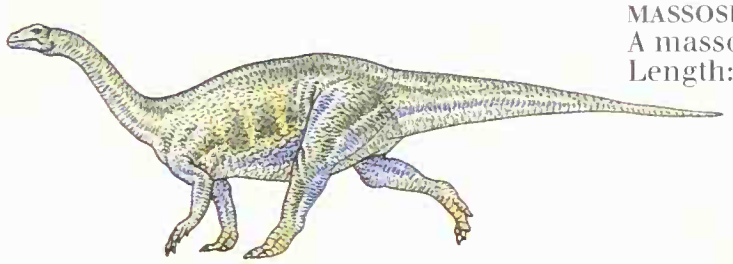


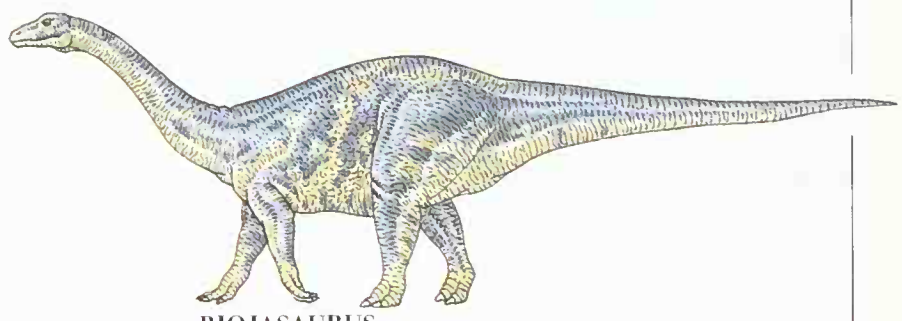

## EXAMPLES OF PROSAUROPODS



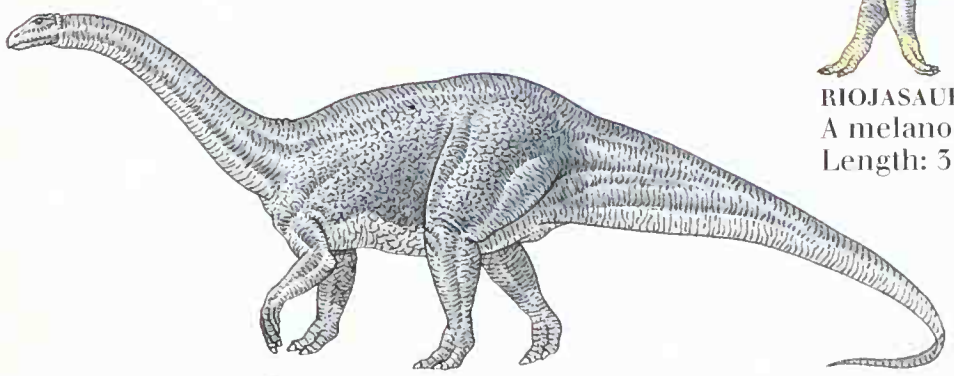
**MASSOSPONDYLUS**
A massospondylid
Length: 13 ft (4 m)



**LUFENGOSAURUS**
A plateosaurid
Length: 20 ft (6.1 m)



**RIOJASAURUS**
A melanorosaurid
Length: 36 ft (11 m)

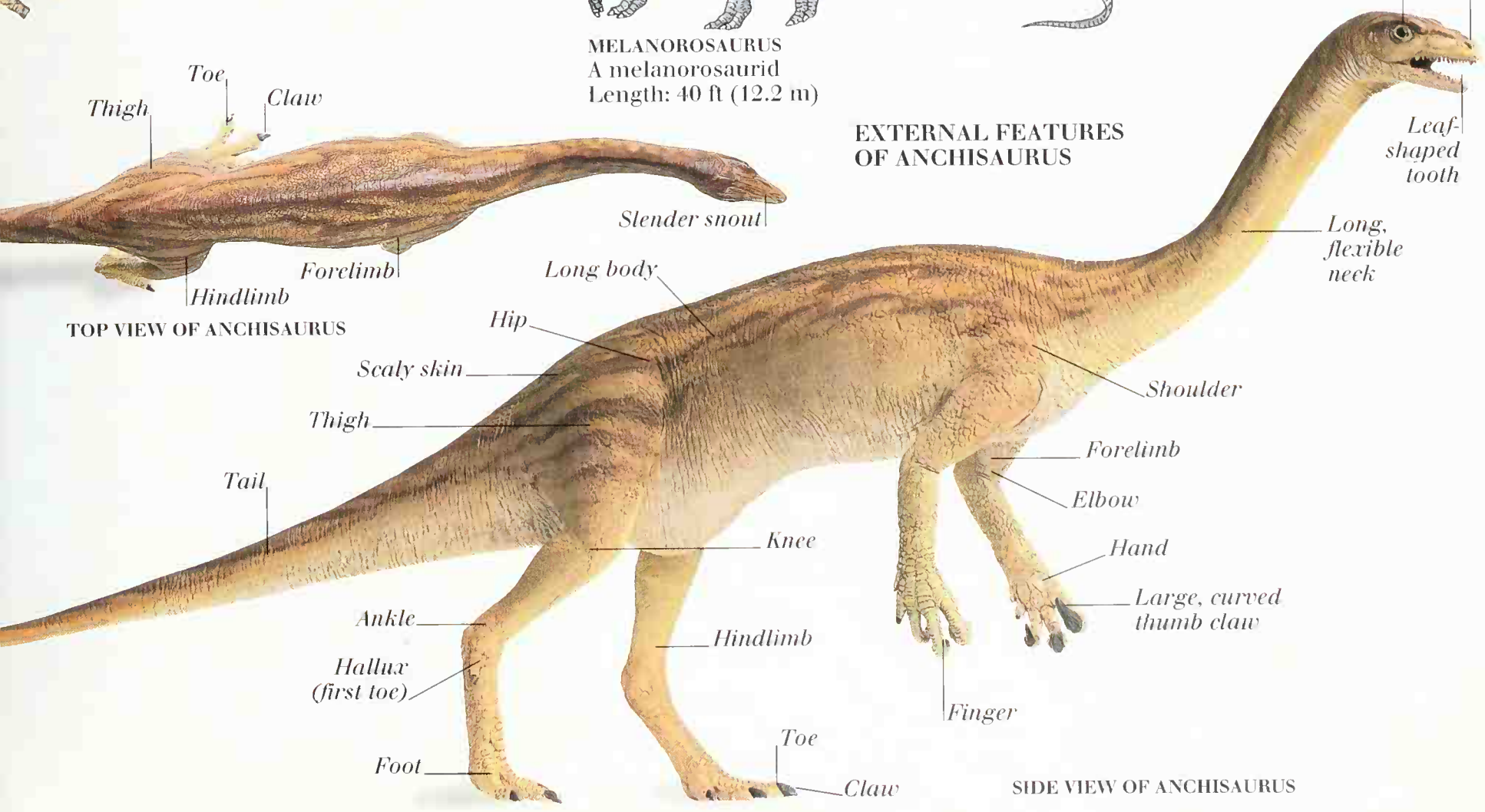


**MELANOROSAURUS**
A melanorosaurid
Length: 40 ft (12.2 m)




**TOP VIEW OF ANCHISAURUS**

## EXTERNAL FEATURES OF ANCHISAURUS



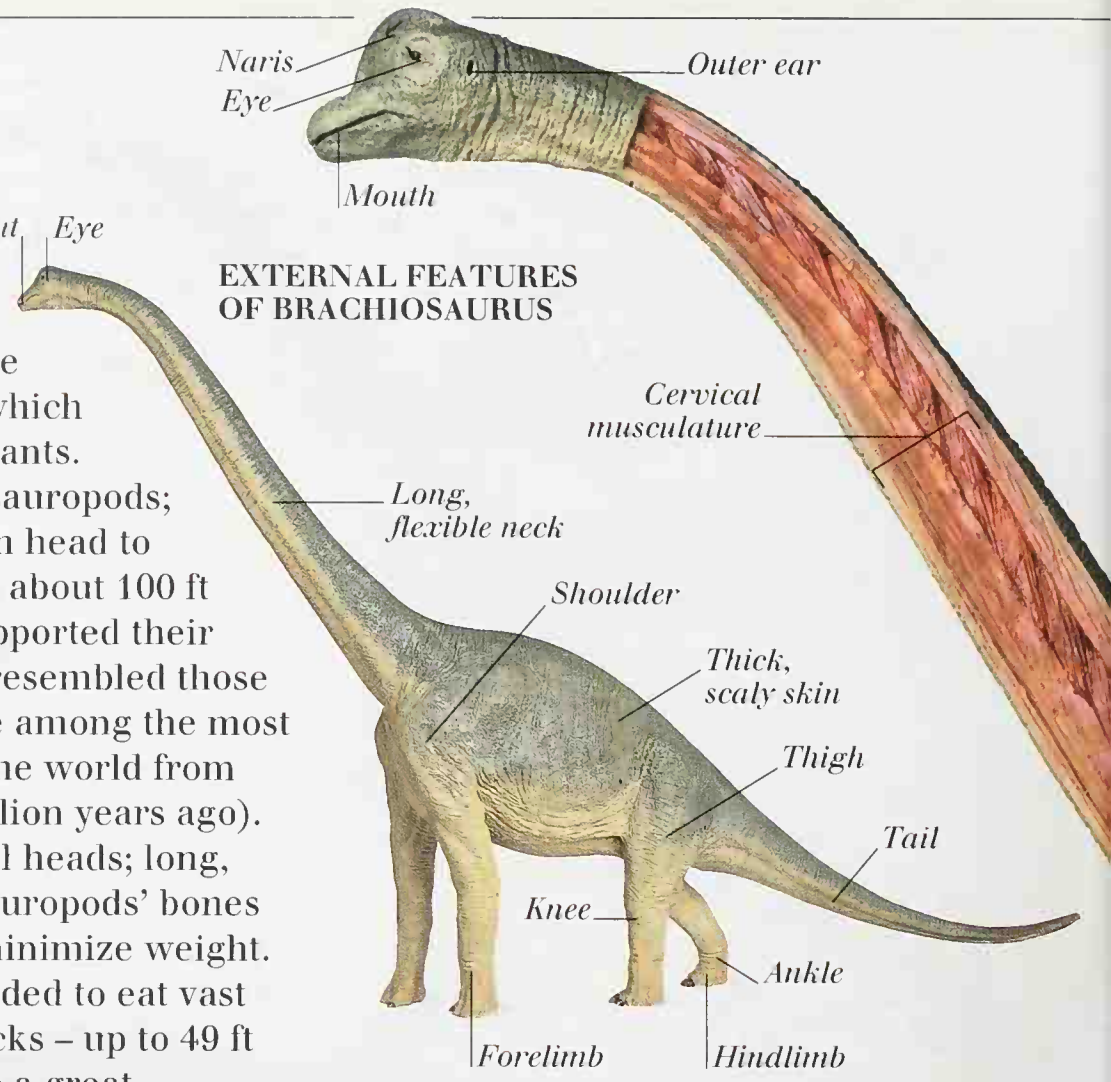

**SIDE VIEW OF ANCHISAURUS**

# Sauropods 1

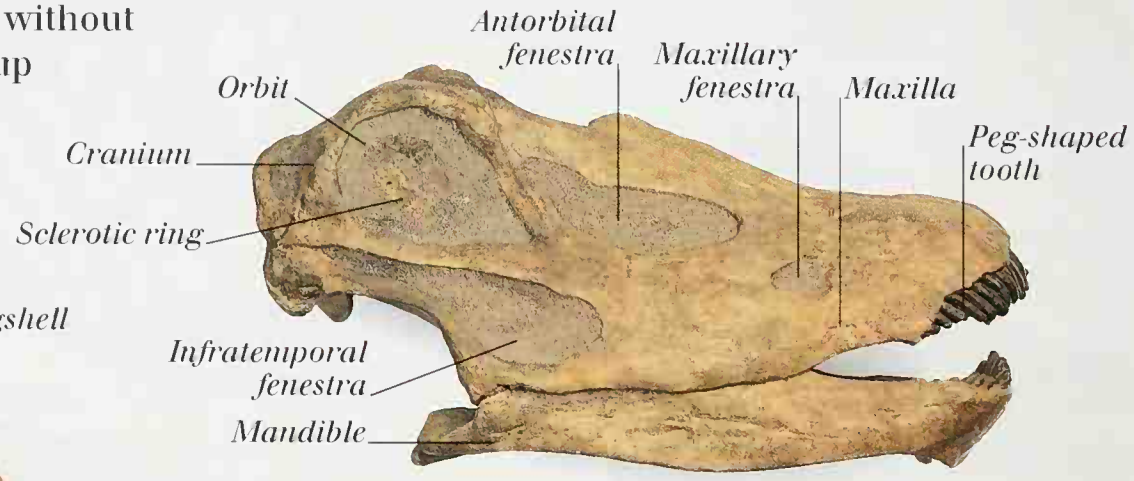
GASTROLITHS (GIZZARD STONES)

SAUROPODS FORMED A large group of saurischian (lizard-hipped) dinosaurs that included some of the largest animals ever to have lived. *Brachiosaurus* was one of the heaviest, weighing up to 77 tons, which is more than the weight of 10 elephants. *Diplodocus* was one of the longest sauropods; measuring about 90 ft (27.4 m) from head to tail, it was almost as long as a blue whale, which, at about 100 ft (30.5 m), is the longest living animal. Sauropods supported their massive weight on pillar-like legs, which probably resembled those of elephants (see p. 28). As a group, sauropods were among the most successful dinosaurs: they were found throughout the world from Early Jurassic to Late Cretaceous times (208–65 million years ago). As well as being huge, sauropods typically had small heads; long, flexible necks; bulky bodies; and long tails. Some sauropods' bones were honeycombed with pleurocoels (hollows) to minimize weight. Sauropods were herbivores and, being so large, needed to eat vast amounts of vegetation. Consequently, their long necks – up to 49 ft (14.9 m) long in the case of *Mamenchisaurus* – were a great advantage, enabling them to reach vegetation that was too high up for other dinosaurs. Sauropods had no grinding teeth, which suggests that they swallowed food without chewing it; instead, food was probably ground up by gastroliths (stones) in the gizzard (muscular stomach).

**EXTERNAL FEATURES OF BRACHIOSAURUS**

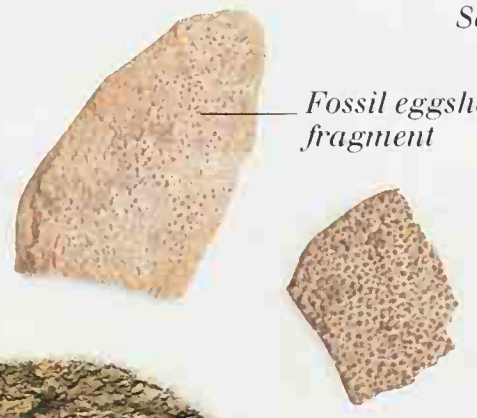



**EXAMPLES OF SAUROPOD SKULLS**



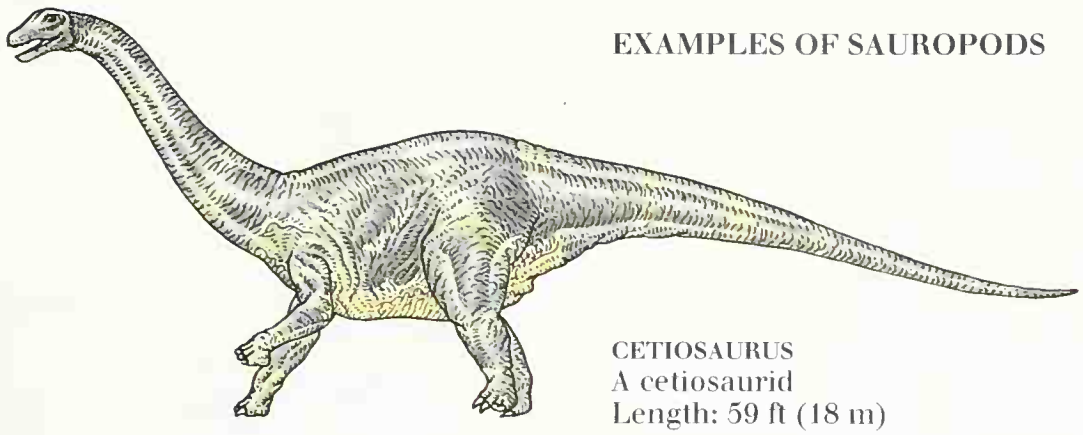

SKULL AND MANDIBLE OF DIPLODOCUS

**FOSSIL EGGS OF TITANOSAURID**

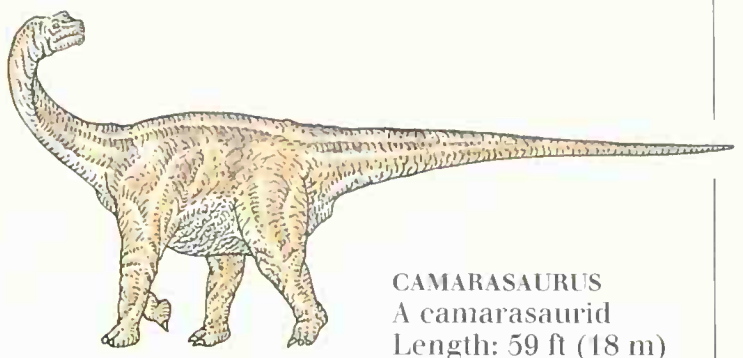


SKULL AND MANDIBLE OF CAMARASAURUS

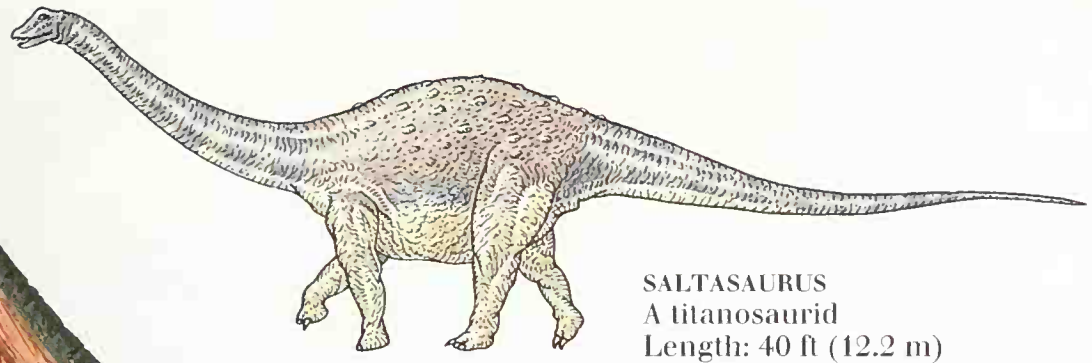
## EXAMPLES OF SAUROPODS



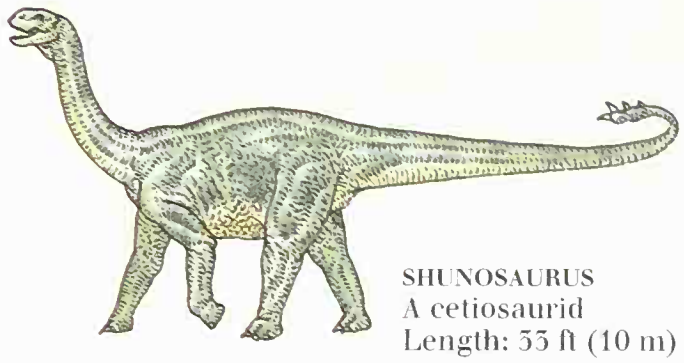
CETIOSAURUS
A cetiosaurid
Length: 59 ft (18 m)



CAMARASAURUS
A camarasaurid
Length: 59 ft (18 m)



SALTASAURUS
A titanosaurid
Length: 40 ft (12.2 m)



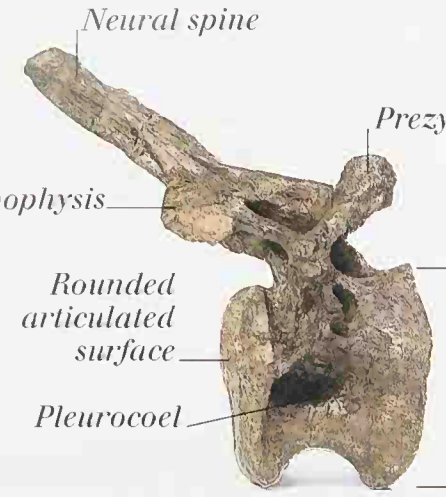
SHUNOSAURUS
A cetiosaurid
Length: 33 ft (10 m)

## INTERNAL ANATOMY OF FEMALE BRACHIOSAURUS

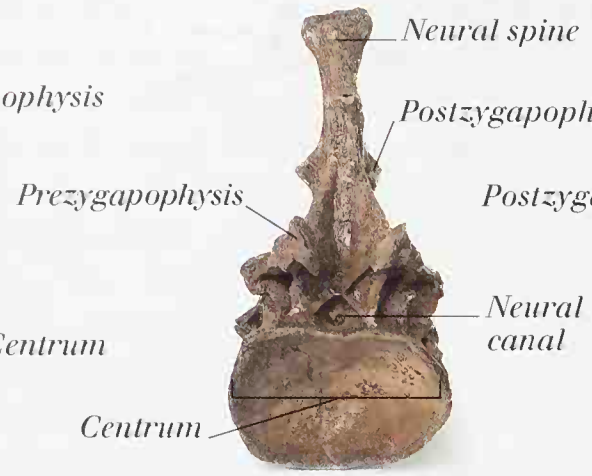
*Cervical vertebra*
*Intercostal muscle*
*Scapula*
*Lung*
*Dorsal vertebra*
*Neural spine*
*Small intestine*
*Ovary*
*Kidney*
*Rib*
*Hip joint*
*Femur*
*Oviduct*
*Cloaca*
*Caudal musculature*
*Trachea*
*Esophagus*
*Scapular muscle*
*Shoulder joint*
*Humerus*
*Anterior brachial muscle*
*Posterior brachial musculature*
*Elbow joint*
*Radius*
*Ulna*
*Posterior antebrachial musculature*
*Wrist joint*
*Metacarpal*
*Gizzard*
*Large intestine*
*Heart*
*Cecum*
*Pubis*
*Forelimb*
*Hindlimb*
*Hind foot*
*Forefoot*
*Nail*
*Thigh musculature*
*Knee joint*
*Anterior crural muscle*
*Posterior crural musculature*
*Fibula*
*Ankle joint*
*Metatarsal*

# Sauropods 2

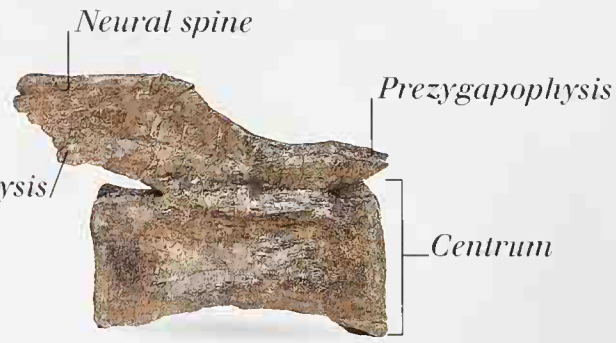
**EXAMPLES OF CAUDAL VERTEBRAE OF BAROSAURUS**



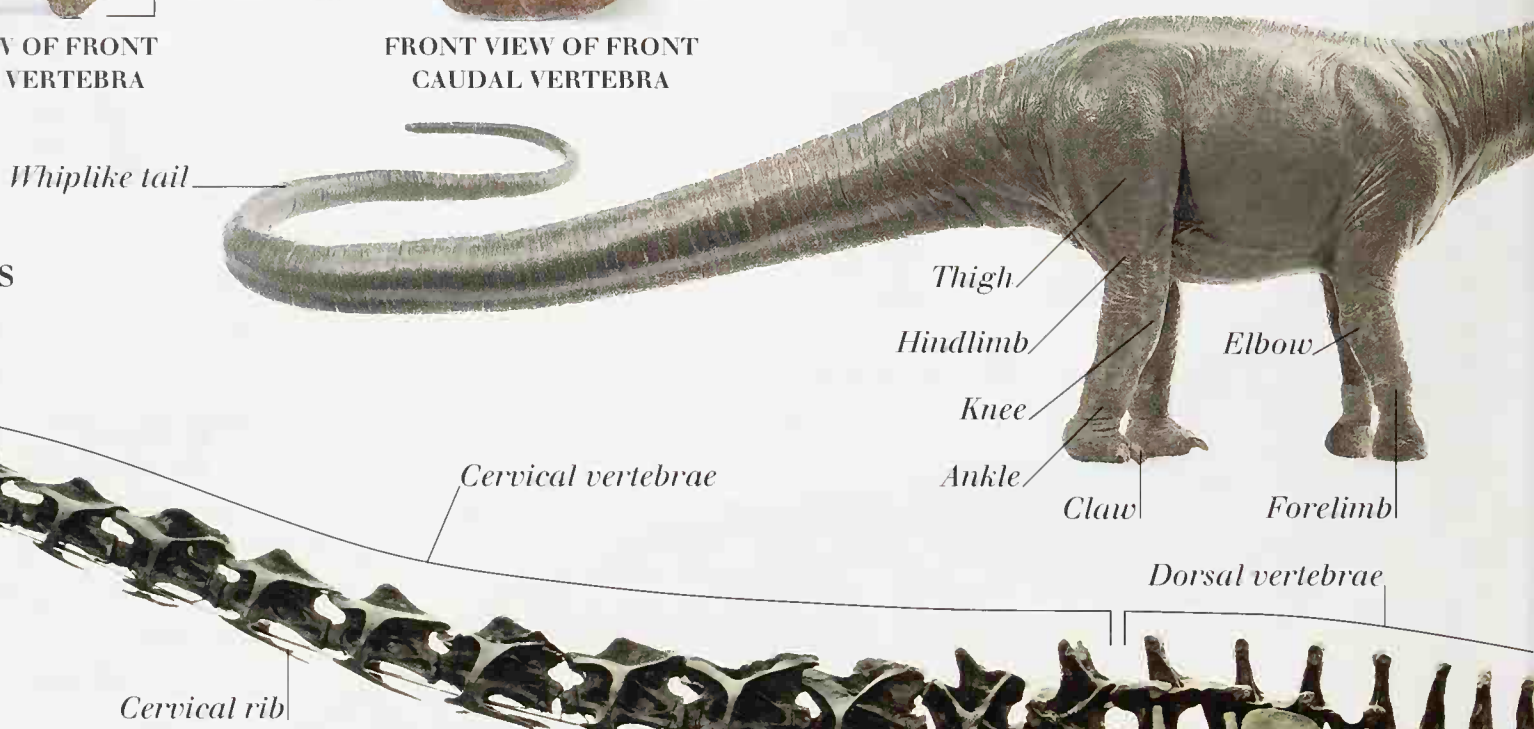

SIDE VIEW OF FRONT CAUDAL VERTEBRA



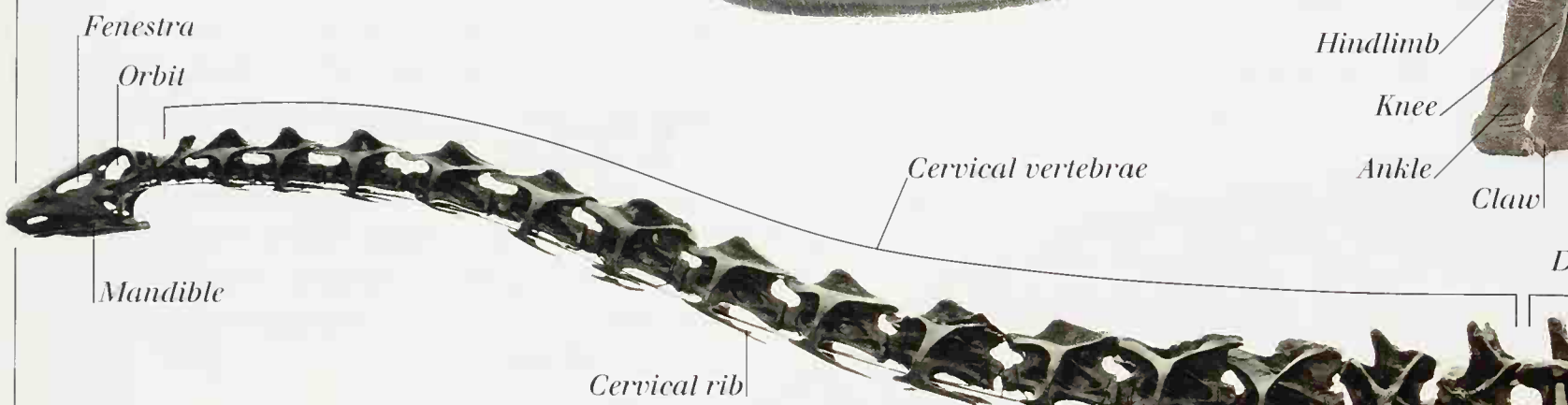

FRONT VIEW OF FRONT CAUDAL VERTEBRA




SIDE VIEW OF MIDDLE CAUDAL VERTEBRA



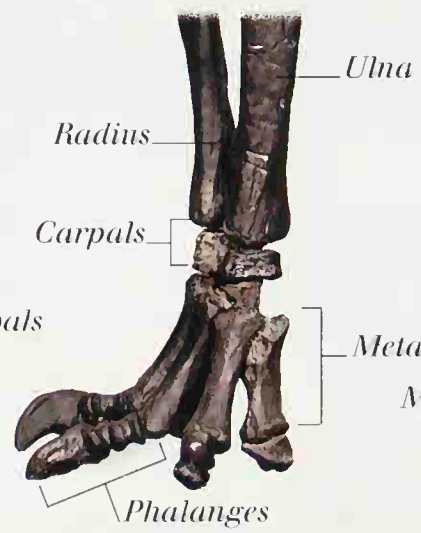

**SKELETON OF DIPLODOCUS**



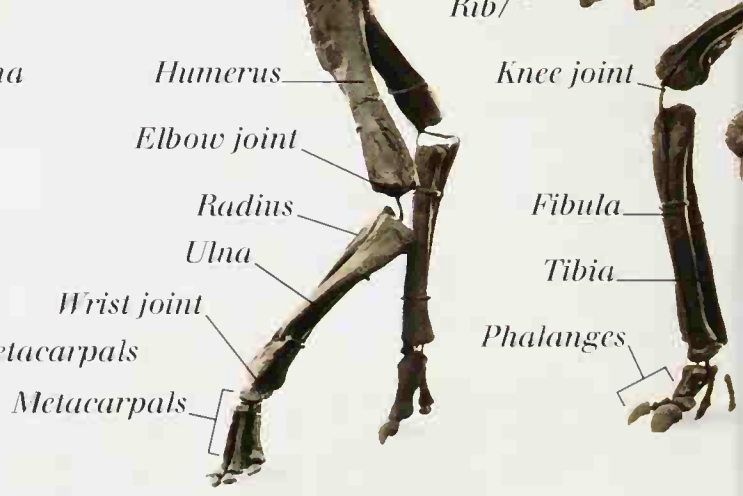

**COMPARISON OF THE FOREFEET OF AN ELEPHANT AND DIPLODOCUS**

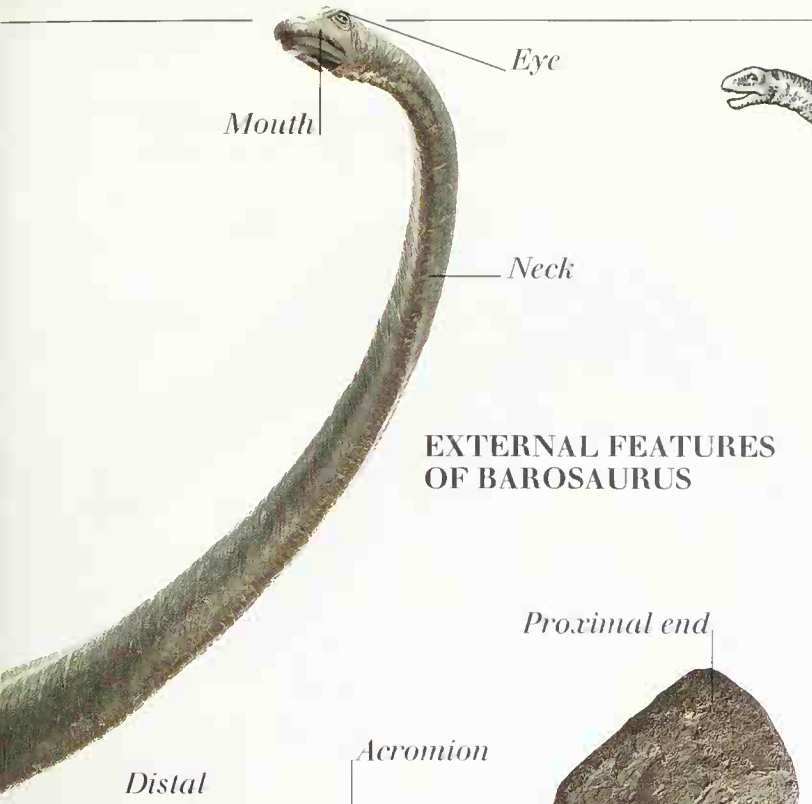
FOREFOOT OF ELEPHANT

FOREFOOT BONES OF ELEPHANT

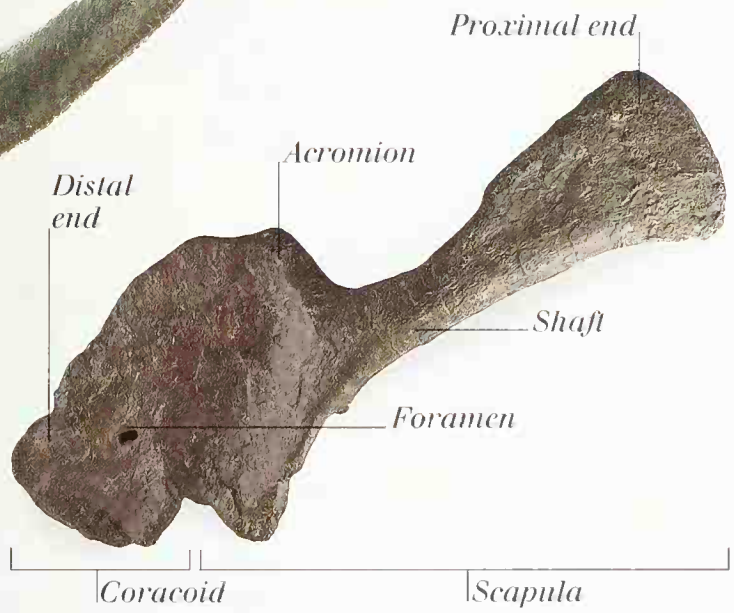



FOREFOOT BONES OF DIPLODOCUS



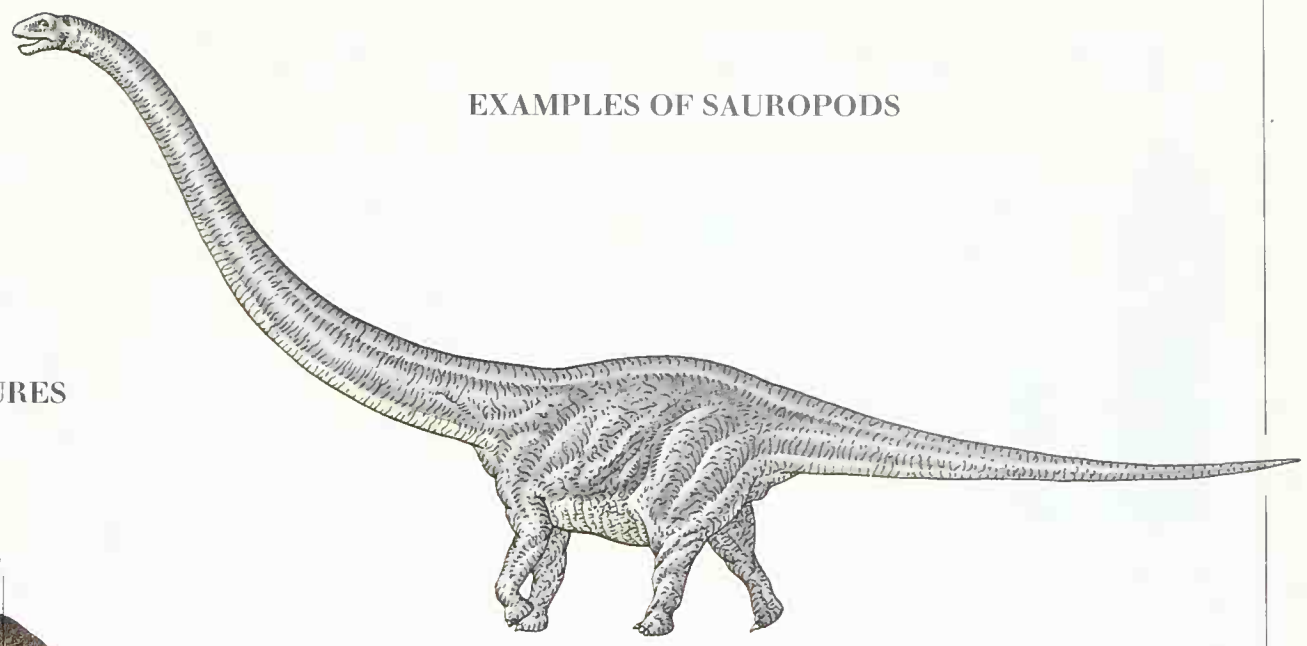



EXTERNAL FEATURES OF BAROSAURUS

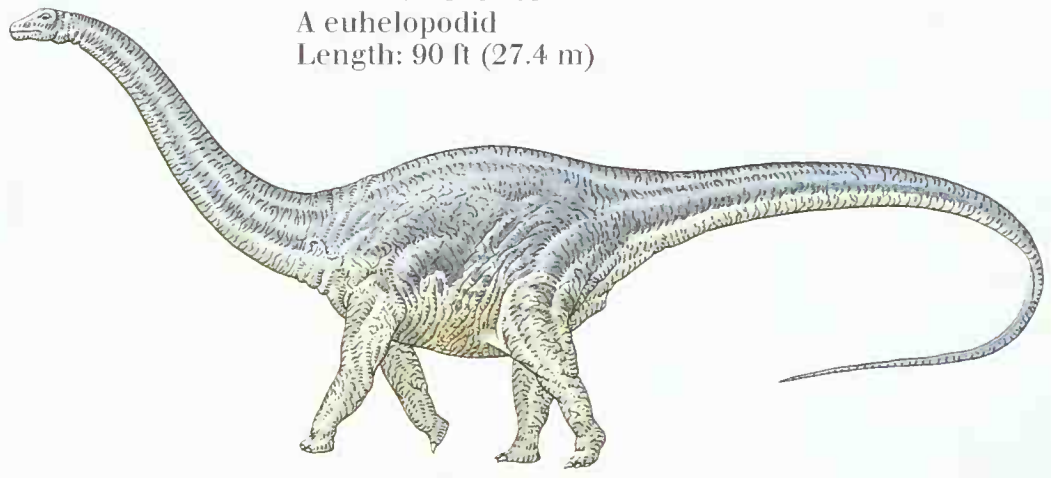



RIGHT SCAPULOCORACOID OF SUPERSAURUS

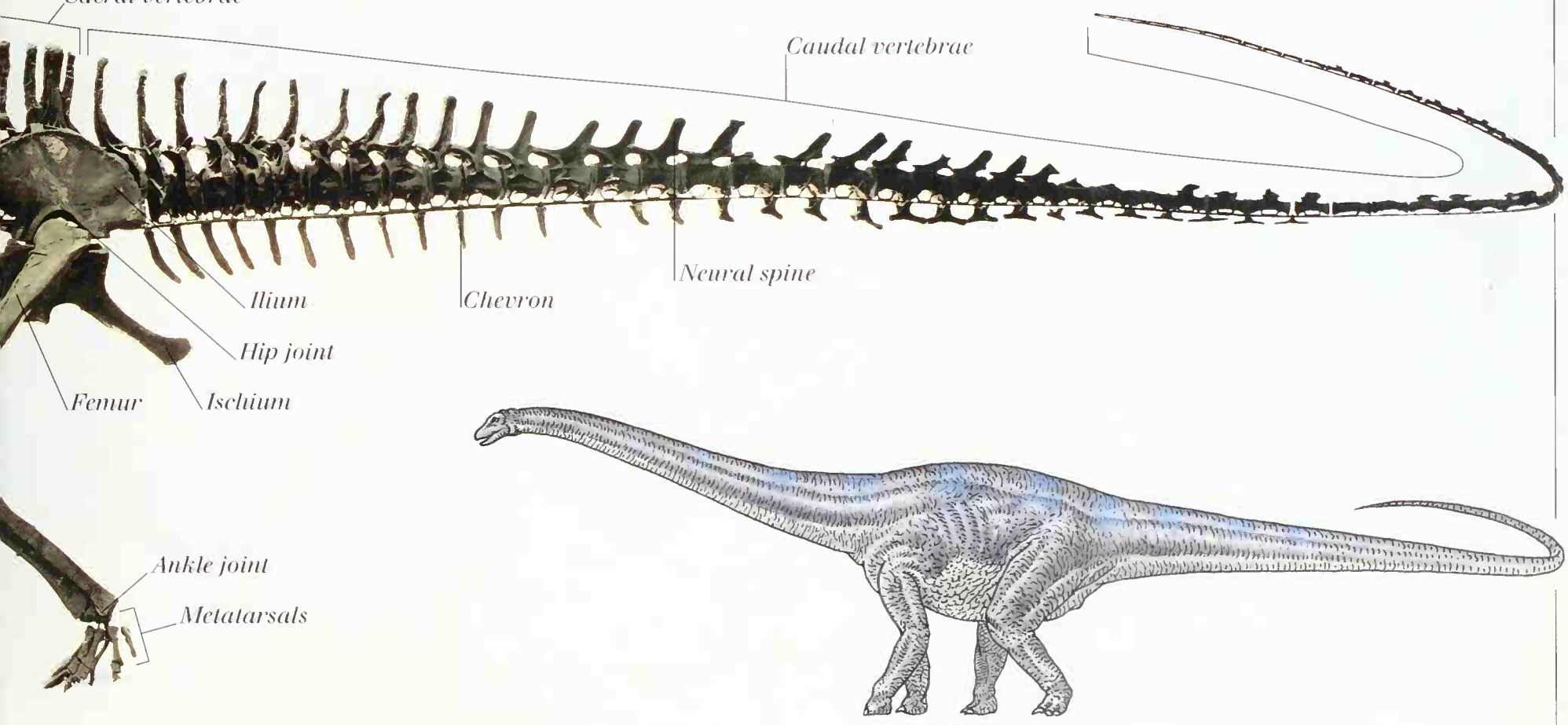
## EXAMPLES OF SAUROPODS



MAMENCHISAURUS
A euhelopodid
Length: 90 ft (27.4 m)



APATOSAURUS
A diplodocid
Length: 70 ft (21.3 m)





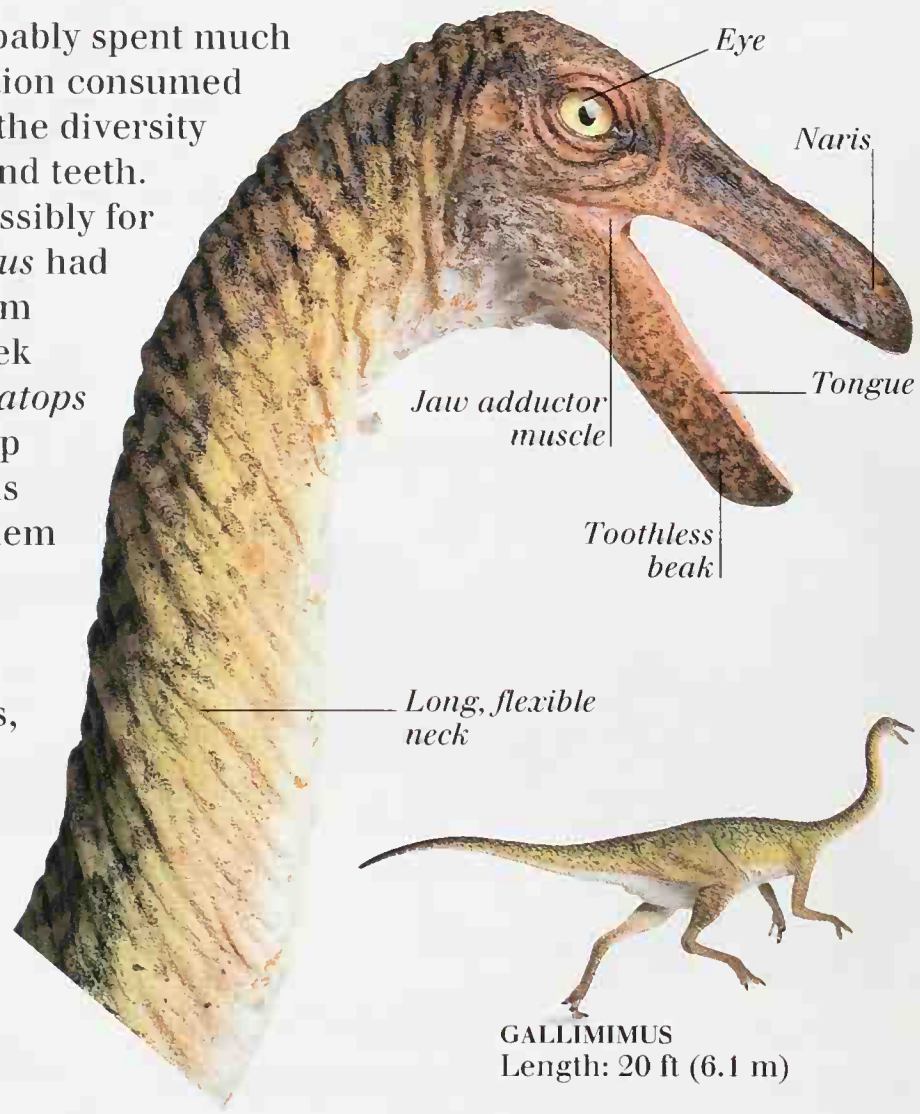

DIPLODOCUS
A diplodocid
Length: 90 ft (27.4 m)

# Herbivores' heads

SAUROPOD TEETH

HERBIVOROUS (PLANT-EATING) DINOSAURS probably spent much of their time eating. The wide range of vegetation consumed by the various herbivores may be reflected in the diversity of their heads, particularly of their jaws and teeth. For example, *Gallimimus* had a beak, possibly for cropping fruit and vegetation, *Anchisaurus* had ridged teeth for shredding the leaves from plants, *Stegosaurus* had a beak, and cheek teeth for grinding vegetation, and *Triceratops* had batteries of cheek teeth for slicing up plant food. The jaws of some herbivorous dinosaurs could move from side to side, which enabled them to grind up vegetation in their mouths. Other herbivores relied on gastroliths (stones) in their gizzard (muscular stomach) to break up the vegetation they had eaten. Most herbivorous dinosaurs had eyes at the sides of their heads, giving them a wide angle of vision so that they could spot predators approaching from any direction. Some herbivores had distinctive features on their heads. For example, *Triceratops* had massive brow horns, possibly for use in territorial battles, and hadrosaurs, such as *Brachylophosaurus*, had crests that distinguished one species from another within a herd.

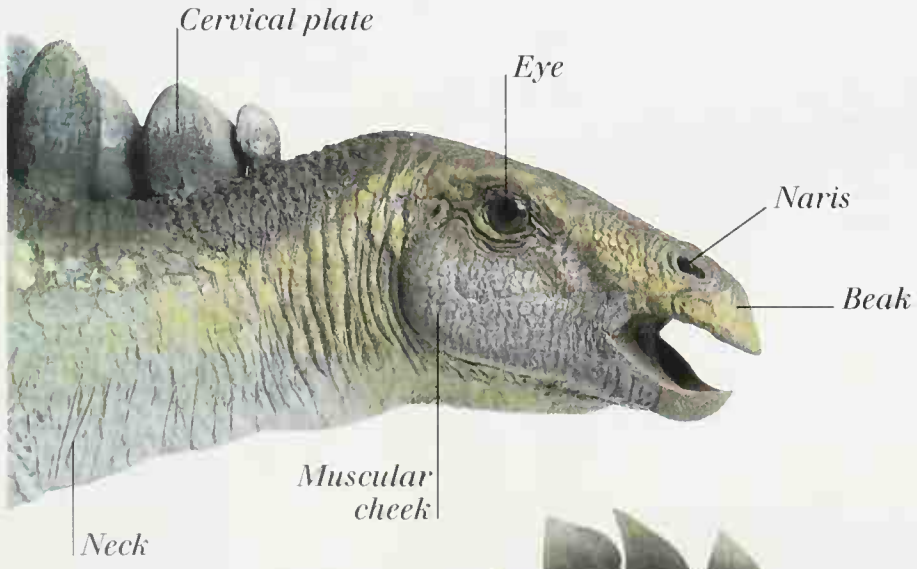
**HEAD OF GALLIMIMUS**





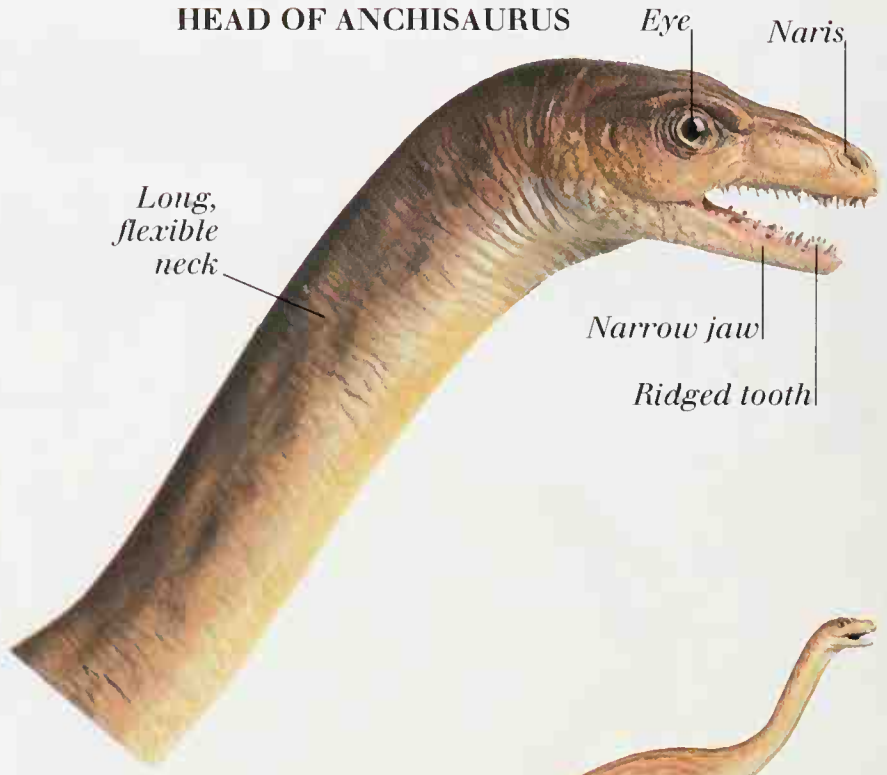

GALLIMIMUS
Length: 20 ft (6.1 m)

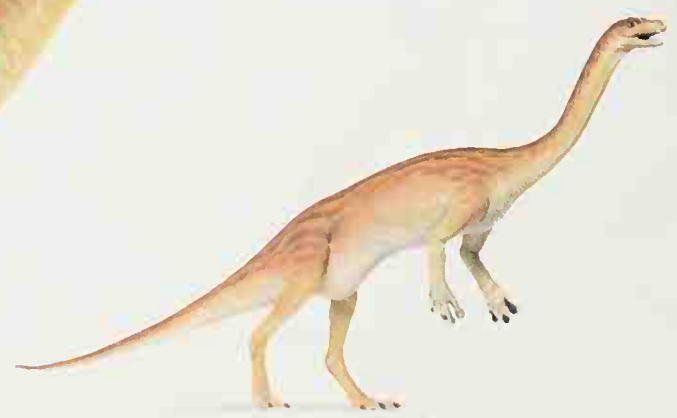
**HEAD OF STEGOSAURUS**



STEGOSAURUS
Length: 30 ft (9.1 m)

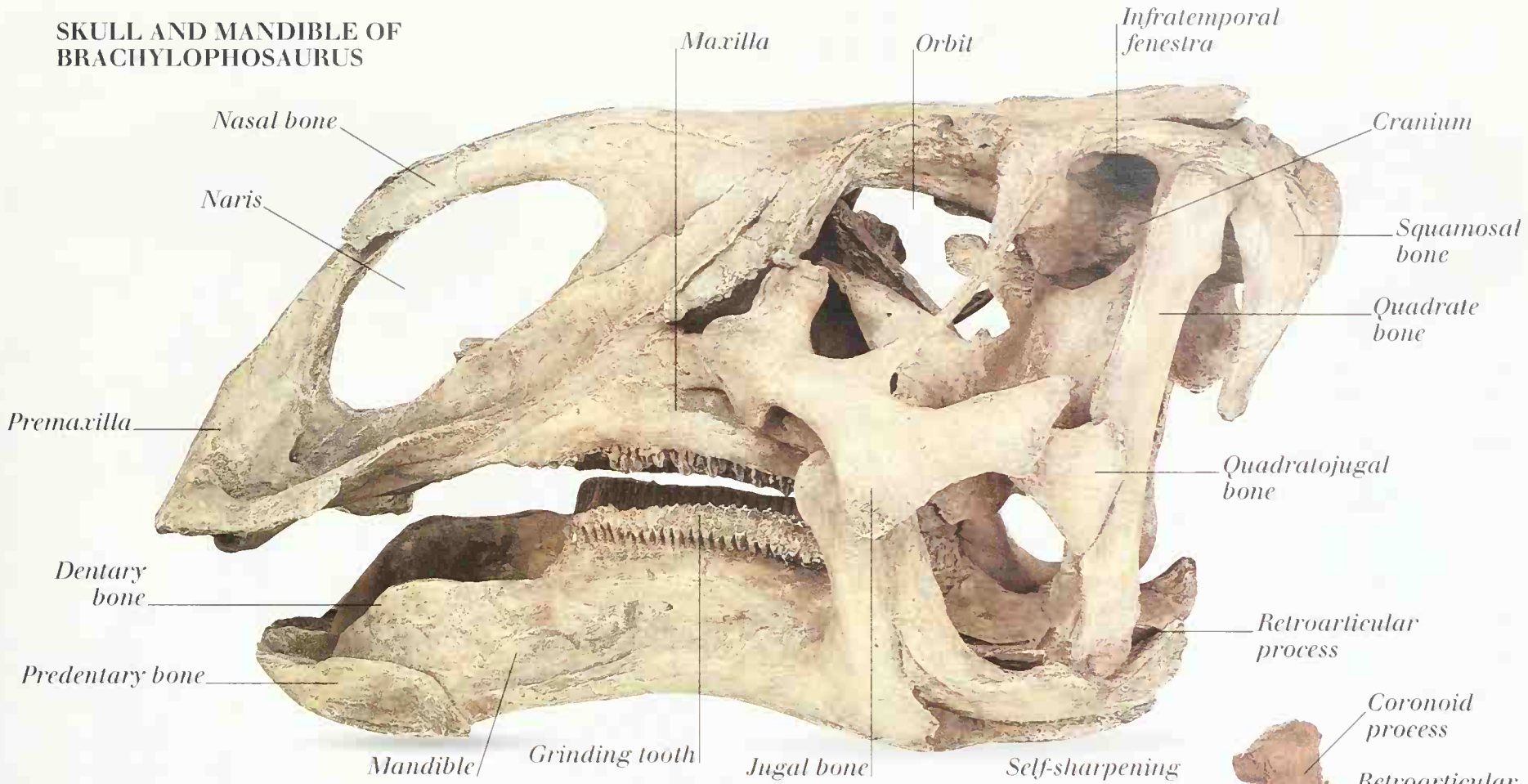
**HEAD OF ANCHISAURUS**



ANCHISAURUS
Length: 7 ft (2.1 m)

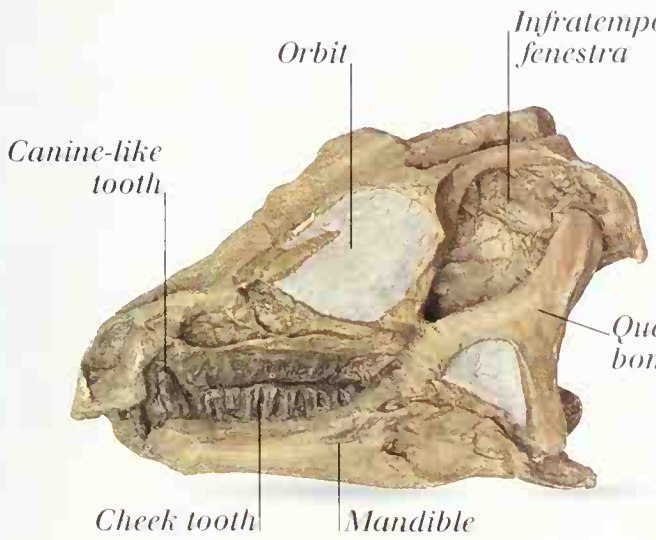
## SKULL AND MANDIBLE OF BRACHYLOPHOSAURUS




BRACHYLOPHOSAURUS
Length: 23 ft (7 m)

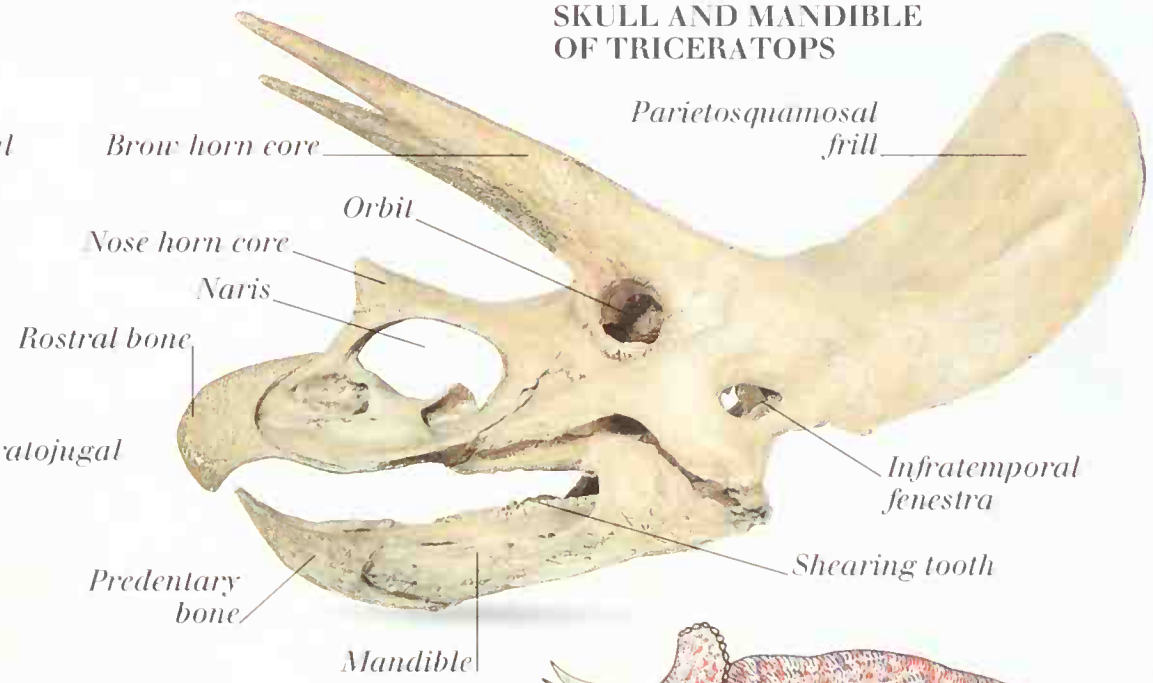
MANDIBLE (LOWER JAW) OF EDMONTOSAURUS

## SKULL AND MANDIBLE OF HETERODONTOSAURUS




HETERODONTOSAURUS
Length: 4 ft (1.2 m)

## SKULL AND MANDIBLE OF TRICERATOPS

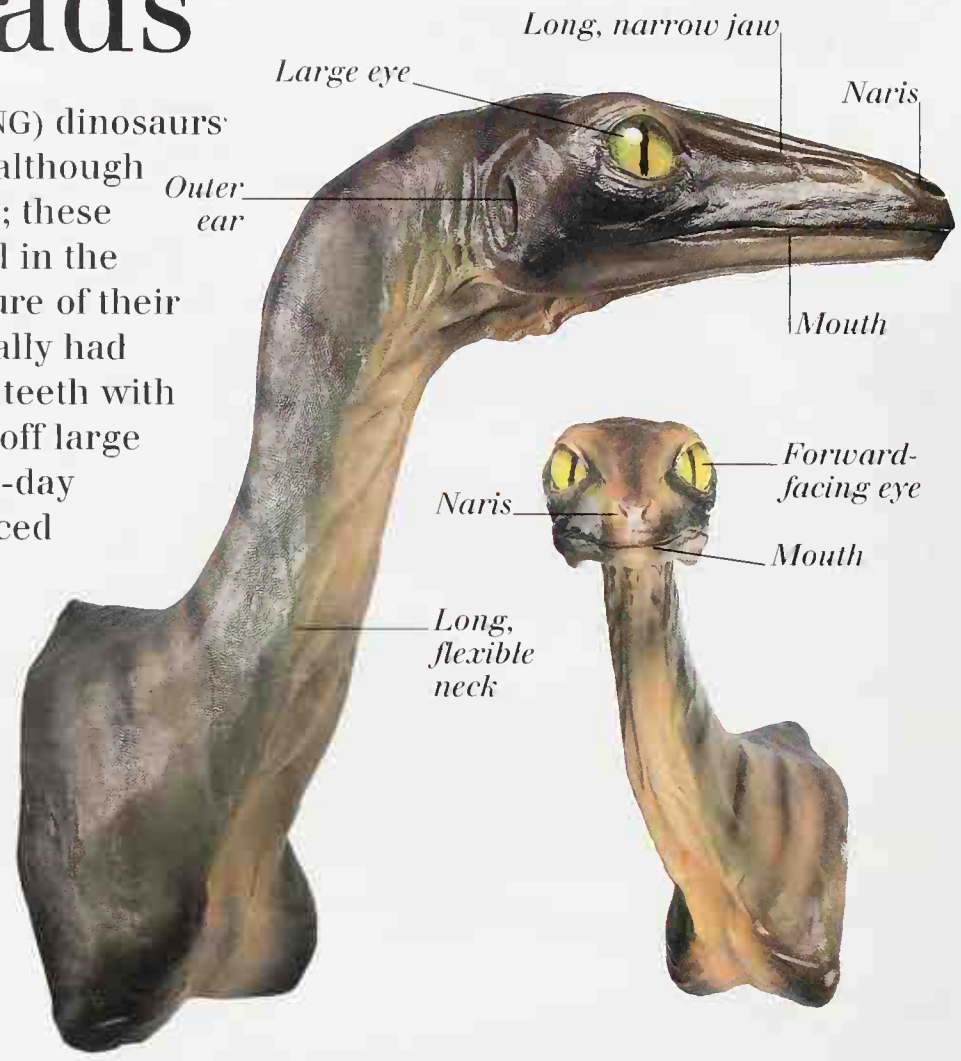



TRICERATOPS
Length: 30 ft (9.1 m)

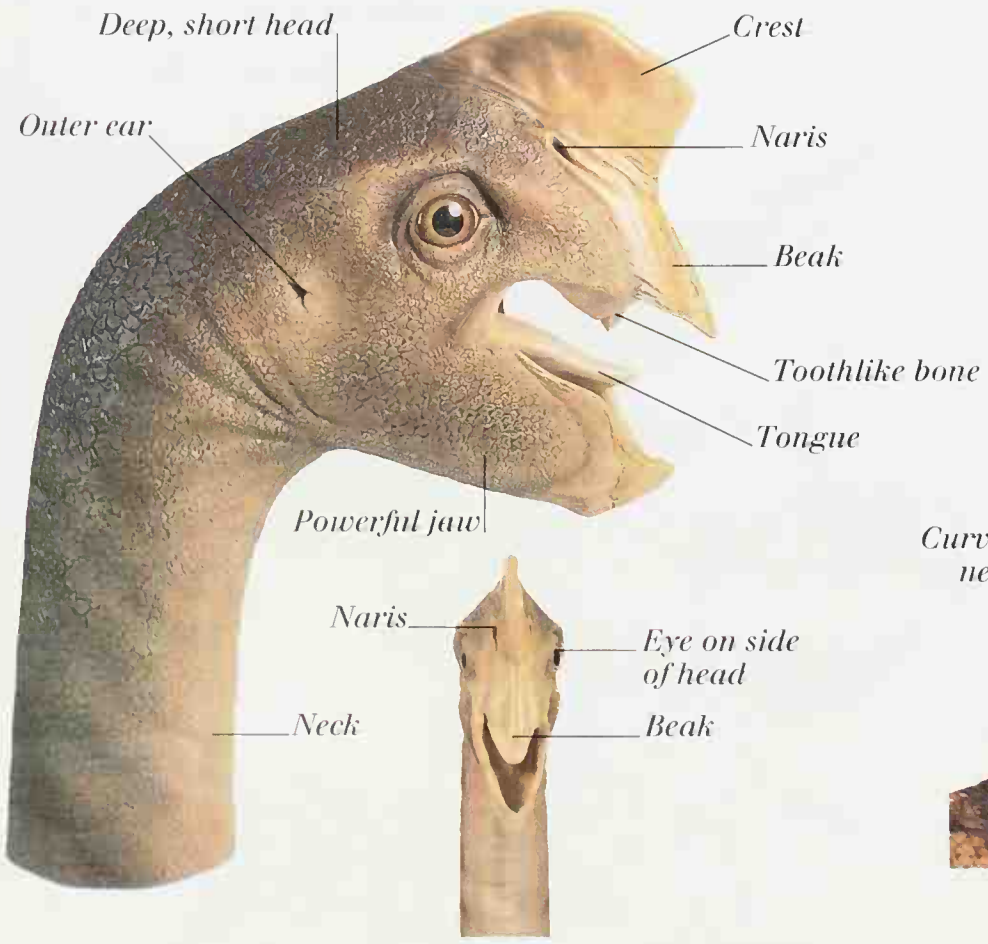
# Carnivores' heads

SKULL AND MANDIBLE OF DILOPHOSAURUS

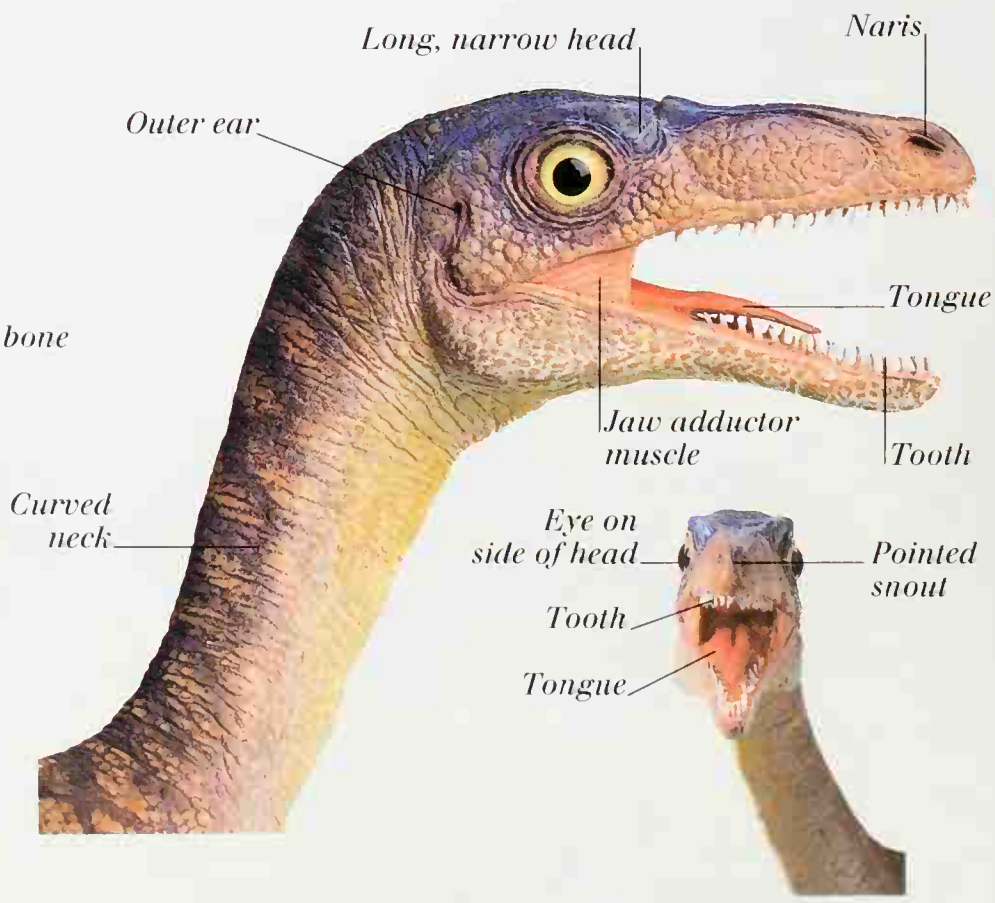
MOST CARNIVOROUS (FLESH-EATING) dinosaurs were probably active predators, although a few may have been scavengers; these flesh-eating life-styles are reflected in the features of their heads and the structure of their skulls. Carnivorous dinosaurs typically had strong jaws containing many sharp teeth with serrated edges to kill prey and tear off large chunks of flesh. As in many present-day carnivorous reptiles, the teeth of dinosaurs were replaced continually throughout their lifetime. Carnivorous dinosaurs did not have grinding teeth, which suggests that they swallowed food without chewing it. Some of their skulls had flexible joints, allowing them to distort slightly to accommodate huge mouthfuls of flesh. Typically, there were also many cavities in the skull, not only to minimize weight, but also to provide space for large, powerful jaw muscles. The heads and skulls of some carnivorous dinosaurs were adapted to specific diets. For example, *Baryonyx* had a crocodile-like skull that may have been adapted for catching fish, while *Oviraptor* had a deep, strong beak that might have been adapted for breaking into the shells of eggs or mollusks.




HEAD OF TROODON

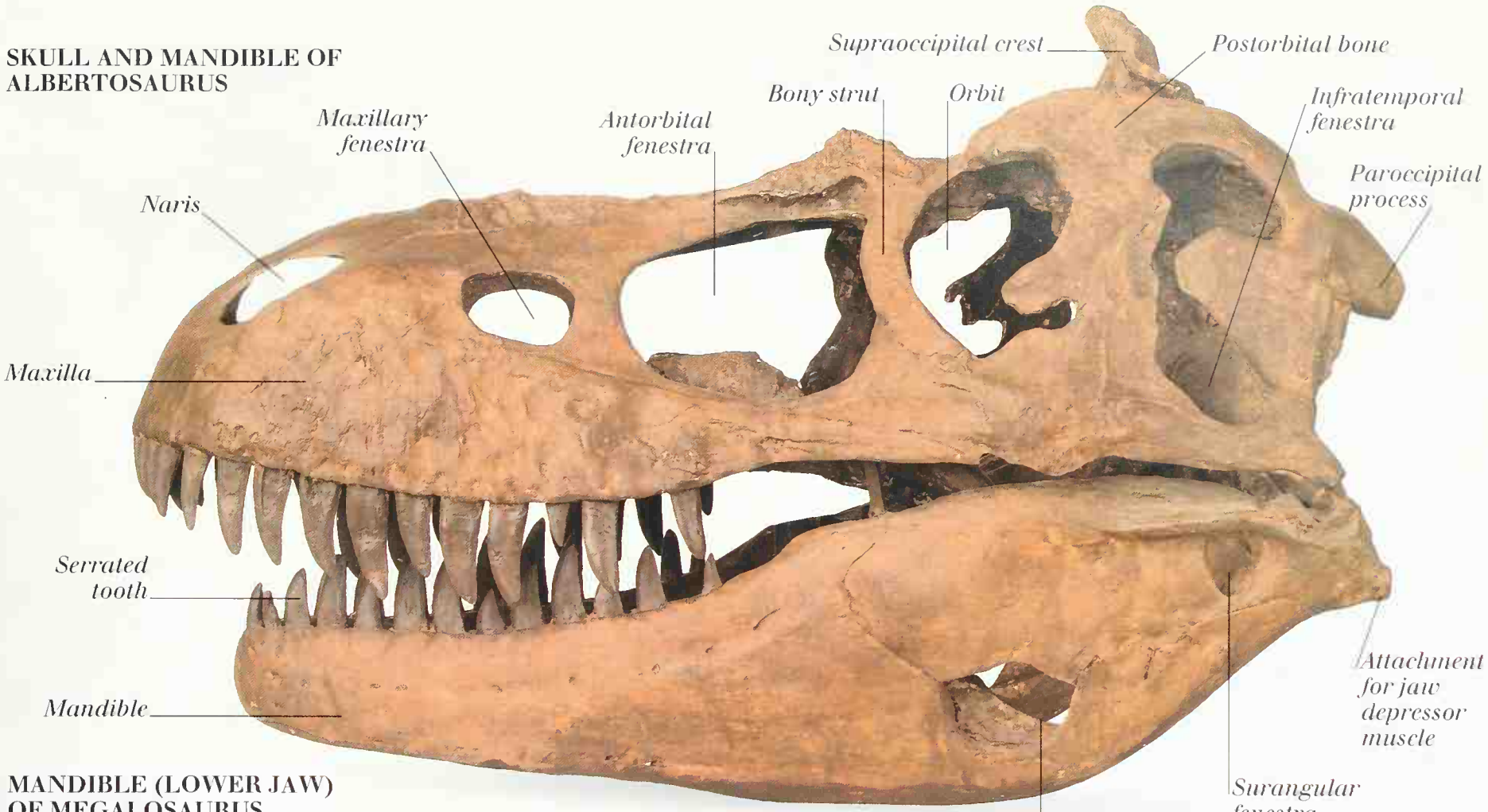



HEAD OF OVIRAPTOR

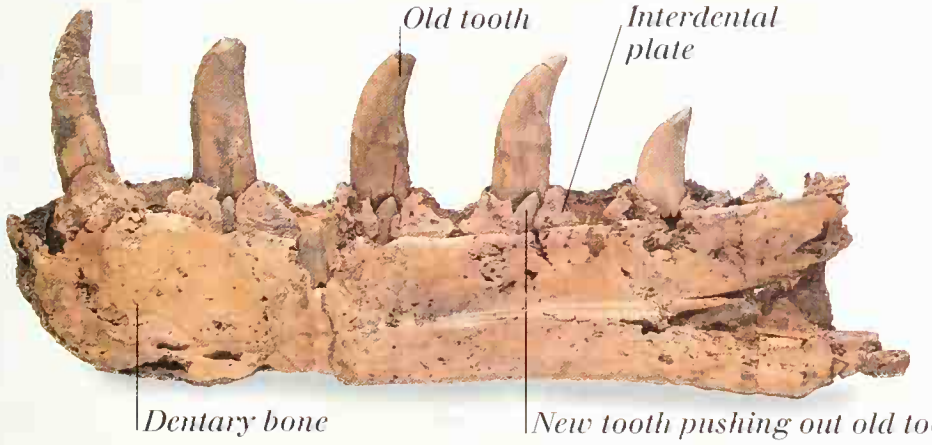


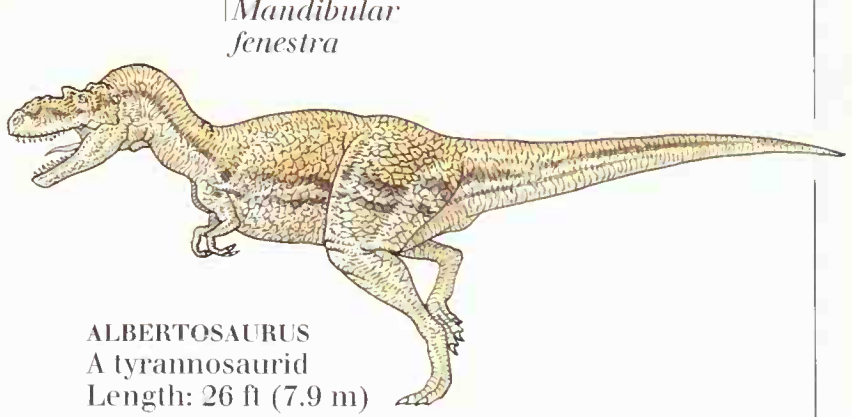

HEAD OF COMPSOGNATHUS

## SKULL AND MANDIBLE OF ALBERTOSAURUS



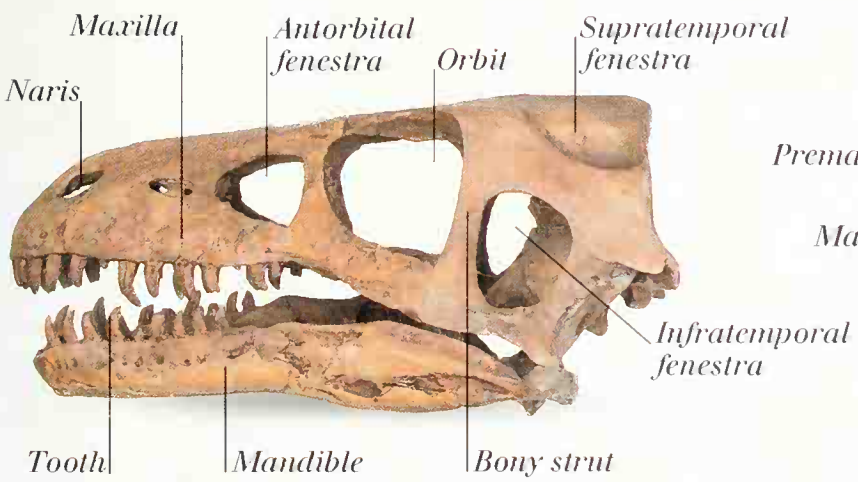

## MANDIBLE (LOWER JAW) OF MEGALOSAURUS



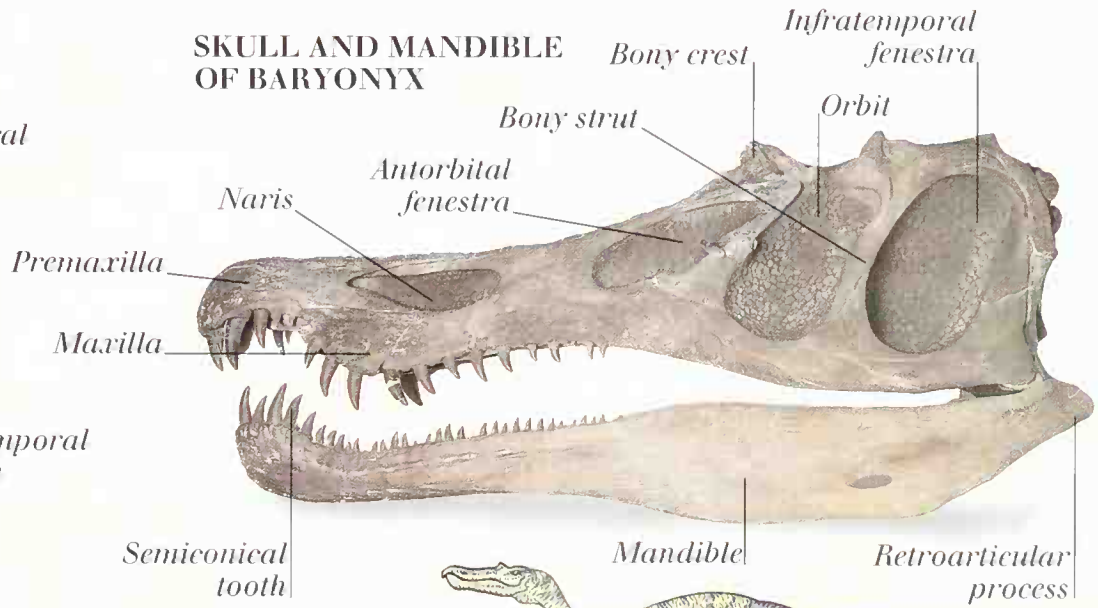
ALBERTOSAURUS
A tyrannosaurid
Length: 26 ft (7.9 m)

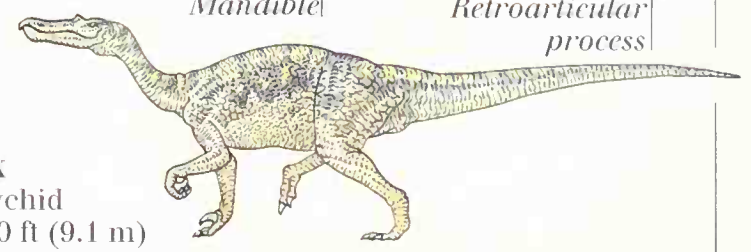
## SKULL AND MANDIBLE OF DROMAEOSAURUS



DROMAEOSAURUS
A dromaeosaurid
Length: 6 ft (1.8 m)

## SKULL AND MANDIBLE OF BARYONYX

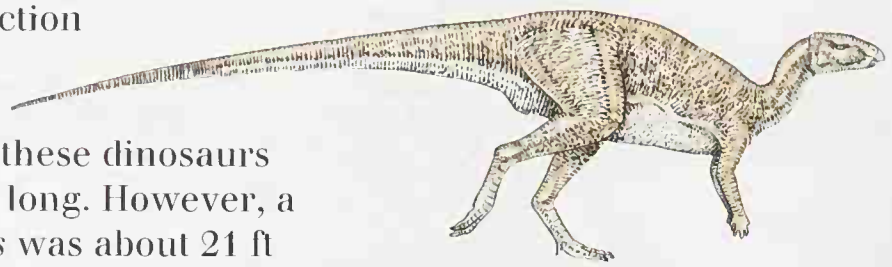


BARYONYX
A baryonychid
Length: 30 ft (9.1 m)

# Small ornithopods

**EXAMPLES OF SMALL ORNITHOPODS**



**ORODROMEUS**
A hypsilophodontid
Length: 8 ft (2.4 m)

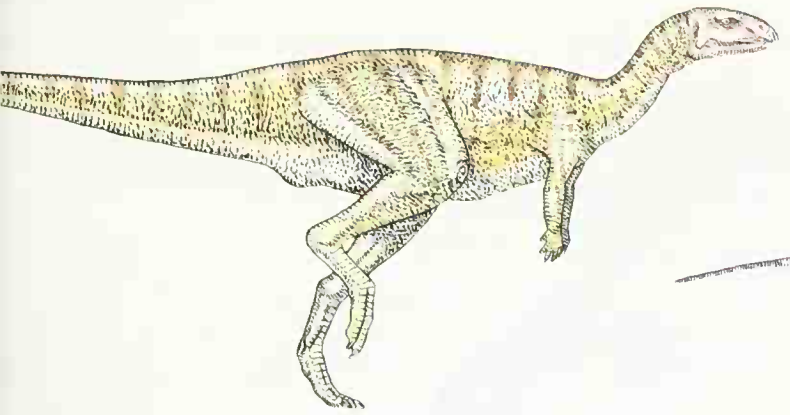
SMALL ORNITHOPODS IS A GENERAL TERM for a varied collection of ornithischian (bird-hipped), herbivorous (plant-eating) dinosaurs that were widespread from Late Triassic to Late Cretaceous times (231–65 million years ago). Most of these dinosaurs were relatively small – typically less than about 13 ft (4 m) long. However, a few were considerably larger. For example, *Tenontosaurus* was about 21 ft (6.4 m) long. Large ornithopods, as their name suggests, were generally bigger than small ornithopods and included iguanodonts (see pp. 36-37) and hadrosaurs (see pp. 38-41). Most small ornithopods had the typical ornithischian arrangement of a toothless beak and cheek teeth for grinding up vegetation. However, the heterodontosaurids (meaning "different-tooth lizards") had three distinct types of teeth – sharp cutting teeth at the front, two pairs of long, canine-like teeth, and broad-ridged cheek teeth at the back of the mouth – an arrangement that is extremely unusual for herbivores of any kind.

**INTERNAL ANATOMY OF MALE HYPSILOPHODON**

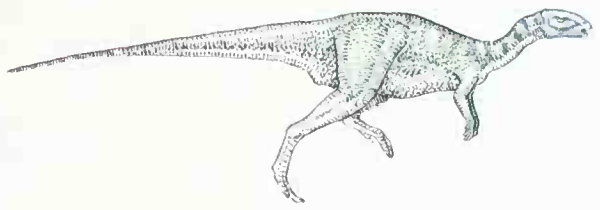
*Eye*
*Scaly skin*
*Dorsal vertebra*
*Small intestine*
*Shoulder joint*
*Gizzard*
*Prepubic process*
*Scapula*
*Rib*
*Kidney*
*Femur*
*Lung*
*Ilium*
*Hip joint*
*Posterior femoral muscle*
*Beak*
*Outer ear*
*Ureter*
*Dorsal tendon*
*Cervical musculature*
*Caudal vertebra*
*Neural spine*
*Coracoid*
*Humerus*
*Elbow joint*
*Liver*
*Radius*
*Large intestine*
*Penis*
*Wrist joint*
*Heart*
*Knee joint*
*Femoral muscle*
*Chevron*
*Tibia*
*Cloaca*
*Pubis*
*Anterior crural muscle*
*Gastrocnemius muscle*
*Hindlimb*
*Fibula*
*Ischium*
*Ankle joint*
*Hallux (first toe)*
*Foot*
*Metatarsal*
*Claw*
*Toe*
*Ulna*

**EXTERNAL FEATURES OF HYPSILOPHODON**

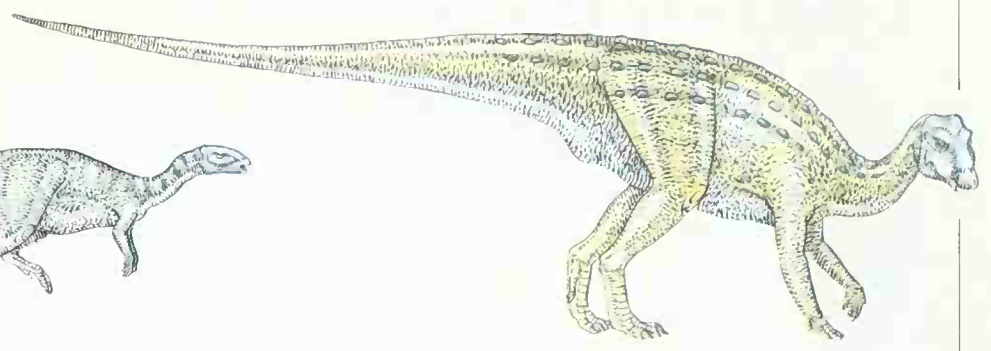
*Eye*
*Cheek*
*Scaly skin*
*Long tail*
*Beak*
*Forelimb*
*Shin*
*Hand*
*Hindlimb*
*Foot*
*Knee*



**DRYOSAURUS**
A dryosaurid
Length: 10–13 ft (3–4 m)

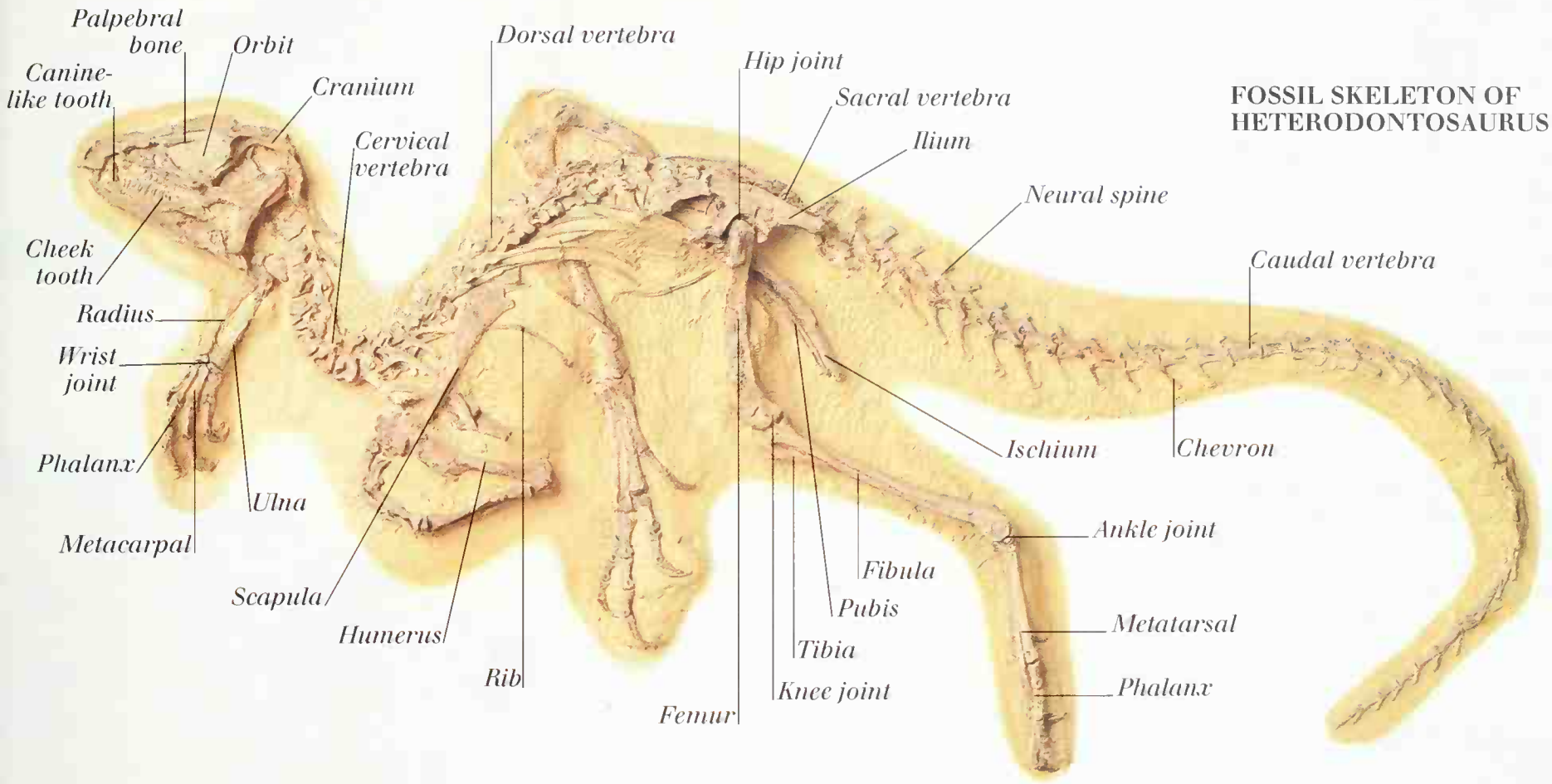


**YANDUSAURUS**
A hypsilophodontid
Length: 5 ft (1.5 m)



**THESCELOSAURUS**
A hypsilophodontid
Length: 11 ft (3.4 m)

**FOSSIL SKELETON OF HETERODONTOSAURUS**



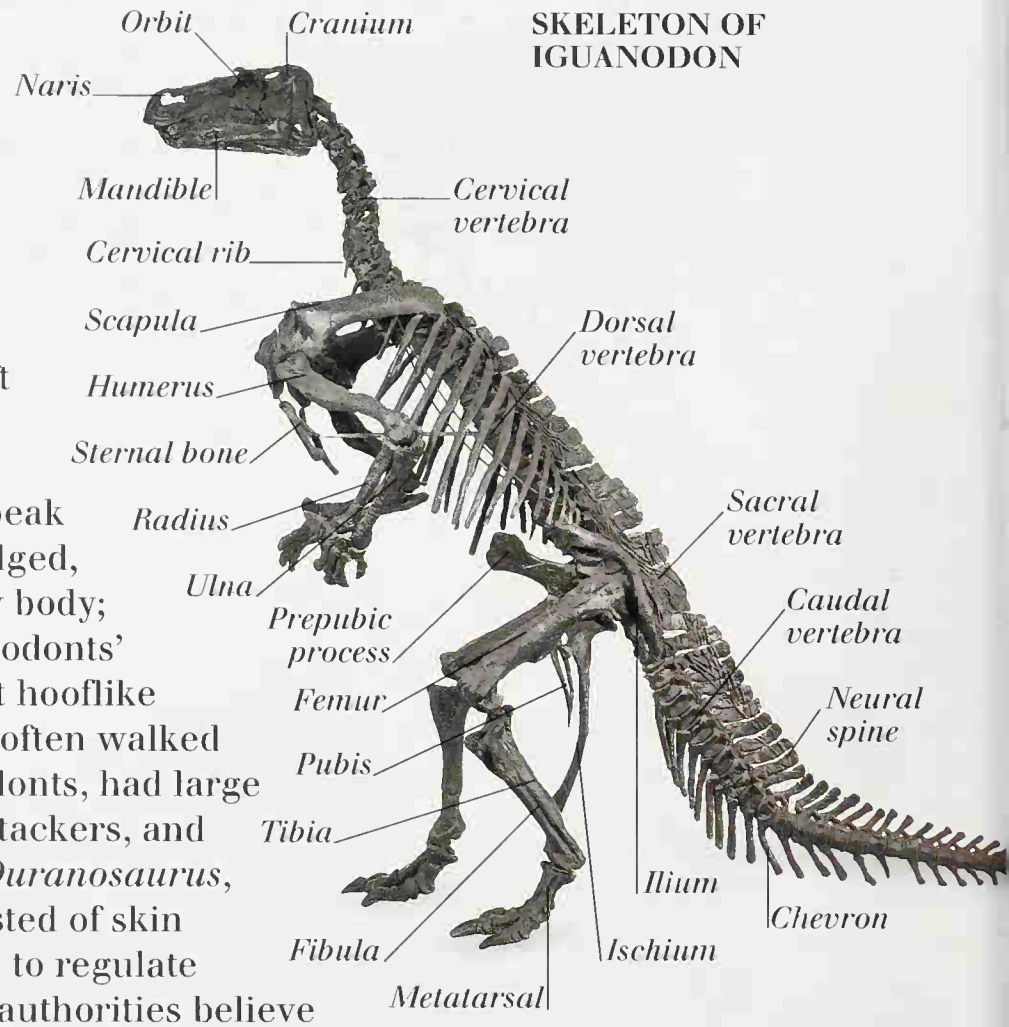
**MODEL OF ORODROMEUS NEST**

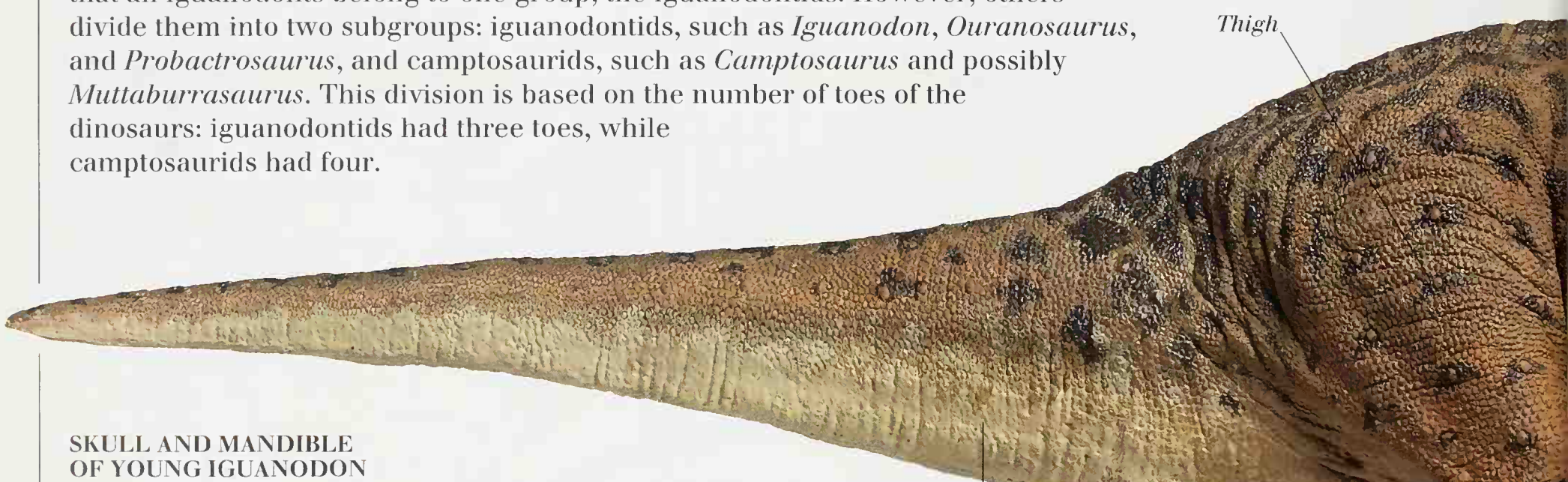
# Iguanodonts

IGUANODON TOOTH

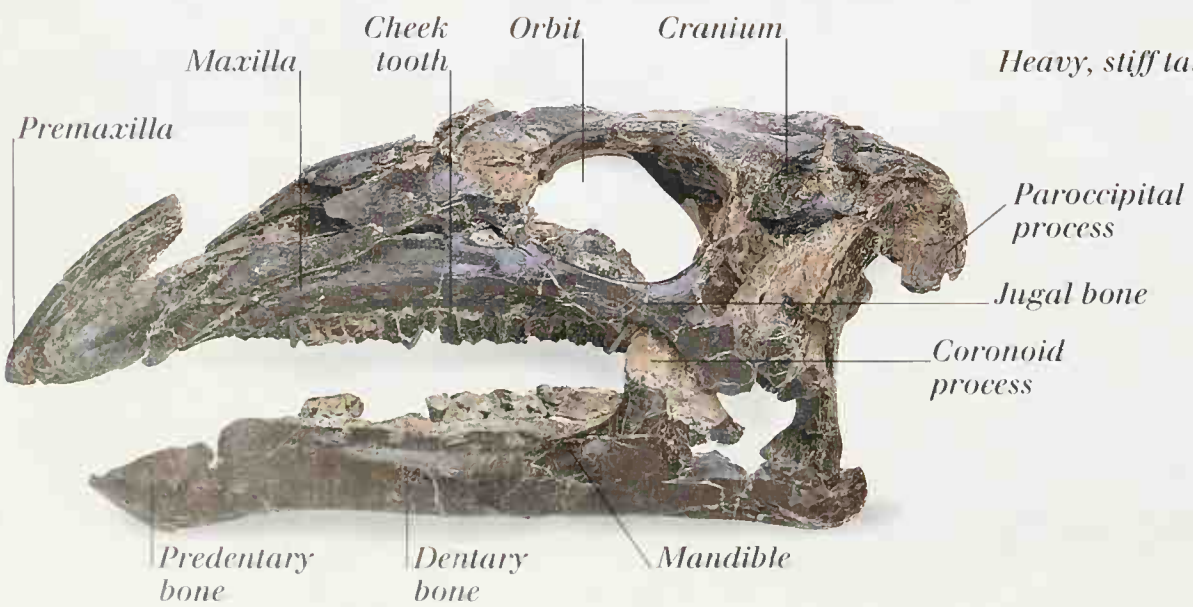
IGUANODONTS WERE A GROUP of herbivorous (plant-eating), ornithischian (bird-hipped) dinosaurs that lived from Late Jurassic to Late Cretaceous times (165–70 million years ago). They were medium- to large-size dinosaurs – between 11 ft 6 in (3.5 m) and 33 ft (10 m) long – and lived in what are now North America, Europe, Africa, Asia, and Australia. Typically, iguanodonts had a broad, toothless beak at the end of a long snout; large jaws with long rows of ridged, close-packed cheek teeth, for grinding vegetation; a bulky body; and a heavy tail that was stiffened by bony tendons. Iguanodonts' powerful hindlimbs enabled them to run from danger, but hooflike nails on their fingers and toes indicate that they probably often walked on all fours. *Iguanodon*, and probably some other iguanodonts, had large thumb spikes that were probably strong enough to stab attackers, and flexible little fingers. The most unusual iguanodont was *Ouranosaurus*, which had a "sail" along its back. The sail probably consisted of skin stretched tightly over upright spines and may have served to regulate body temperature by absorbing and radiating heat. Some authorities believe that all iguanodonts belong to one group, the iguanodontids. However, others divide them into two subgroups: iguanodontids, such as *Iguanodon*, *Ouranosaurus*, and *Probactrosaurus*, and camptosaurids, such as *Camptosaurus* and possibly *Muttaburrasaurus*. This division is based on the number of toes of the dinosaurs: iguanodontids had three toes, while camptosaurids had four.

**SKELETON OF IGUANODON**

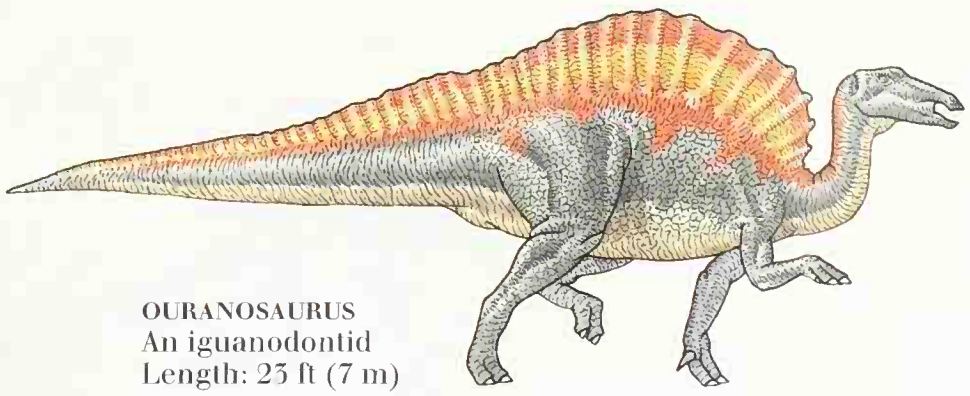


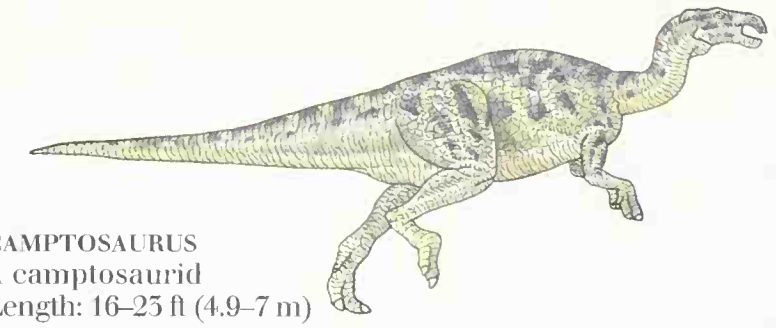

**SKULL AND MANDIBLE OF YOUNG IGUANODON**



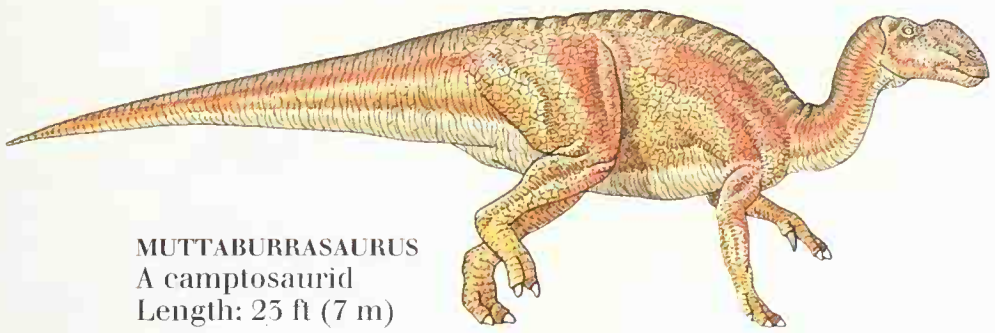
## EXAMPLES OF IGUANODONTS



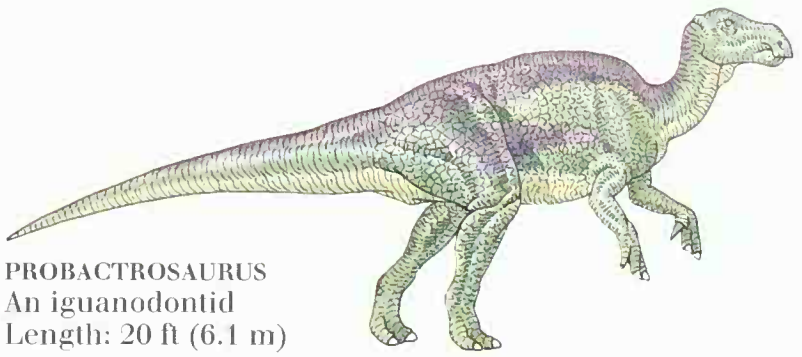
**OURANOSAURUS**
An iguanodontid
Length: 23 ft (7 m)



**CAMPTOSAURUS**
A camptosaurid
Length: 16–23 ft (4.9–7 m)

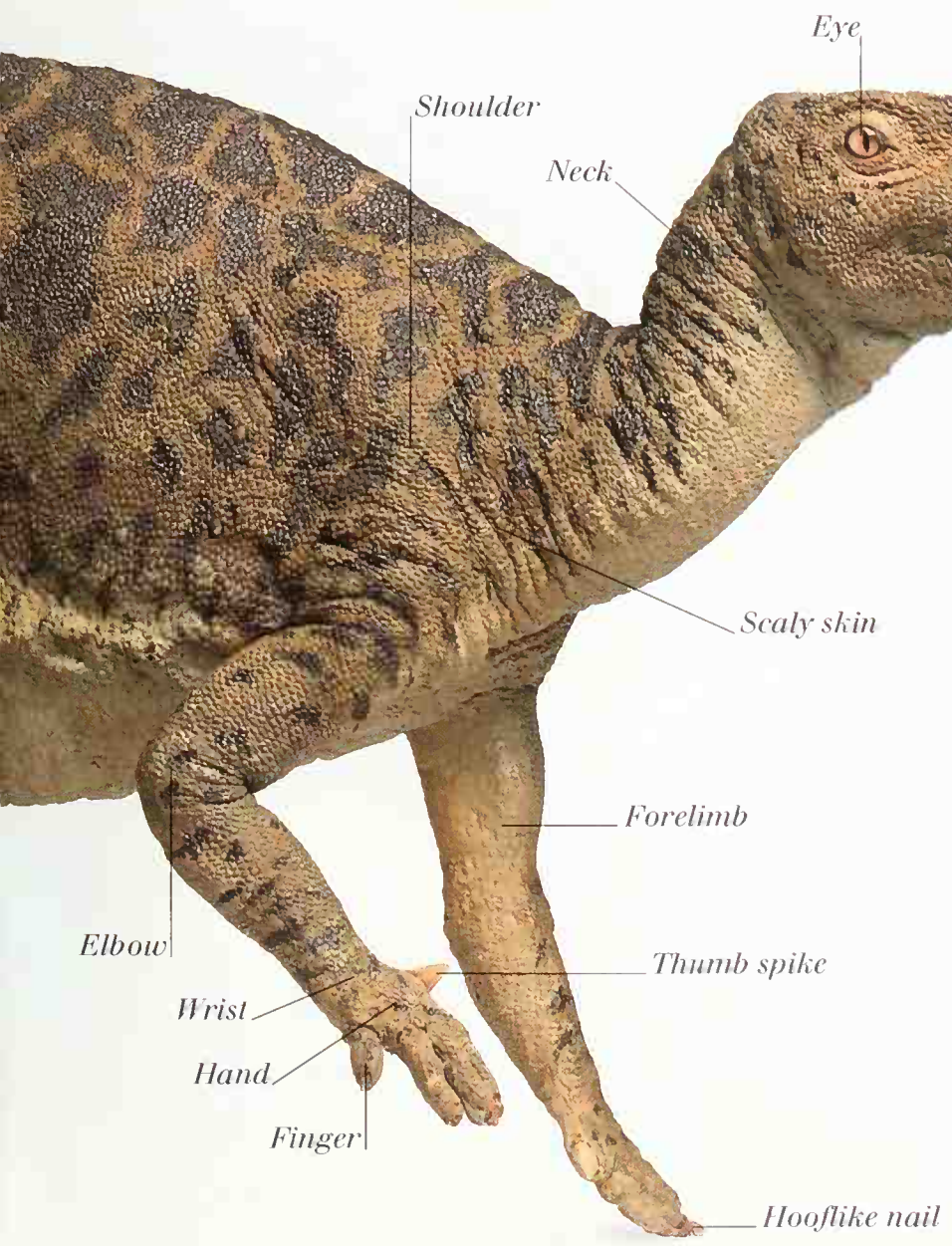


**MUTTABURRASAURUS**
A camptosaurid
Length: 23 ft (7 m)

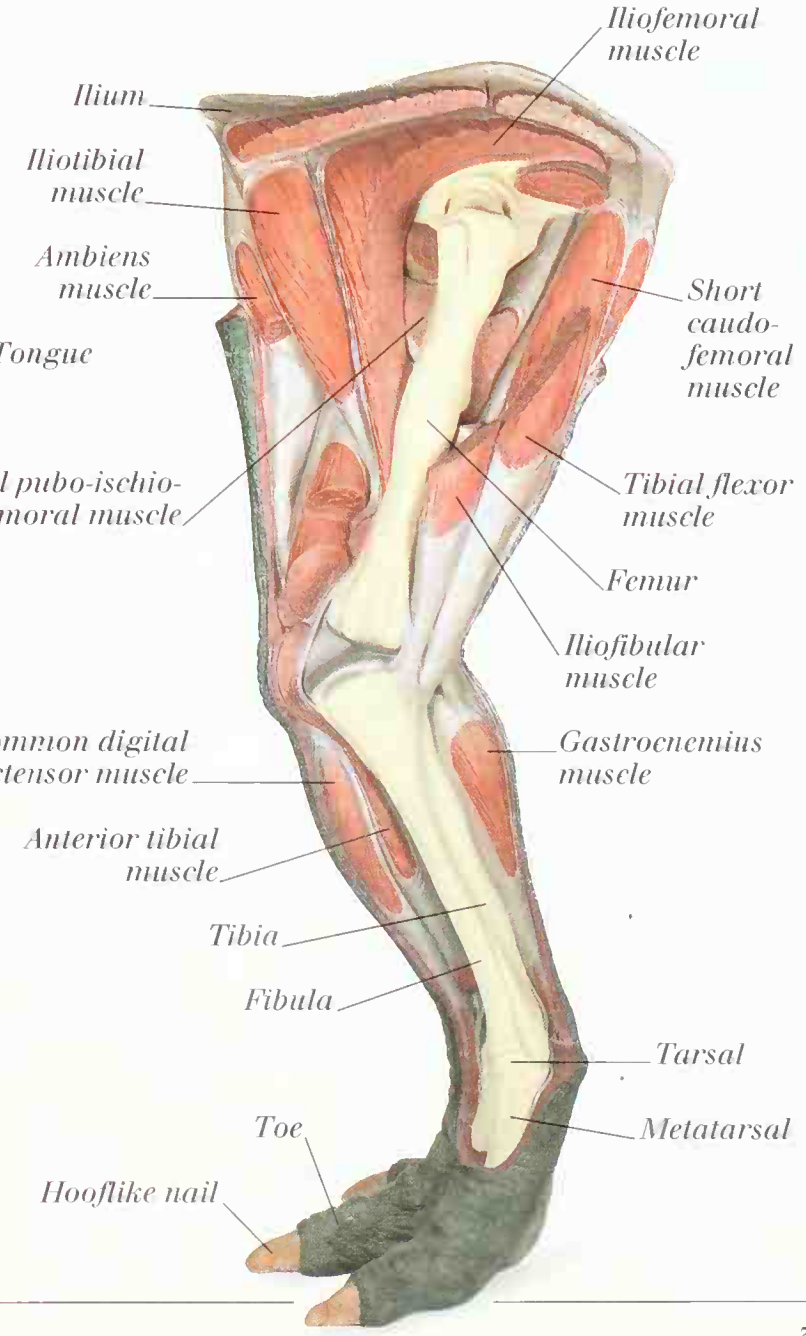


**PROBACTROSAURUS**
An iguanodontid
Length: 20 ft (6.1 m)

## EXTERNAL FEATURES OF IGUANODON




## INTERNAL ANATOMY OF HIND LEG OF IGUANODON

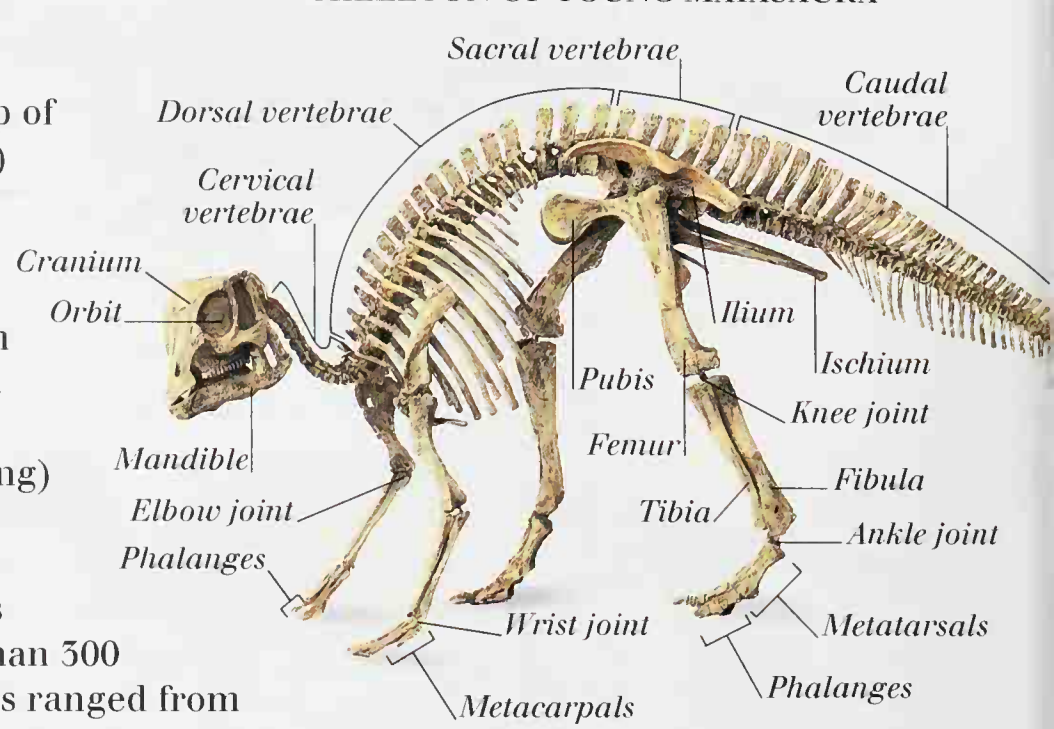


# Hadrosaurs 1

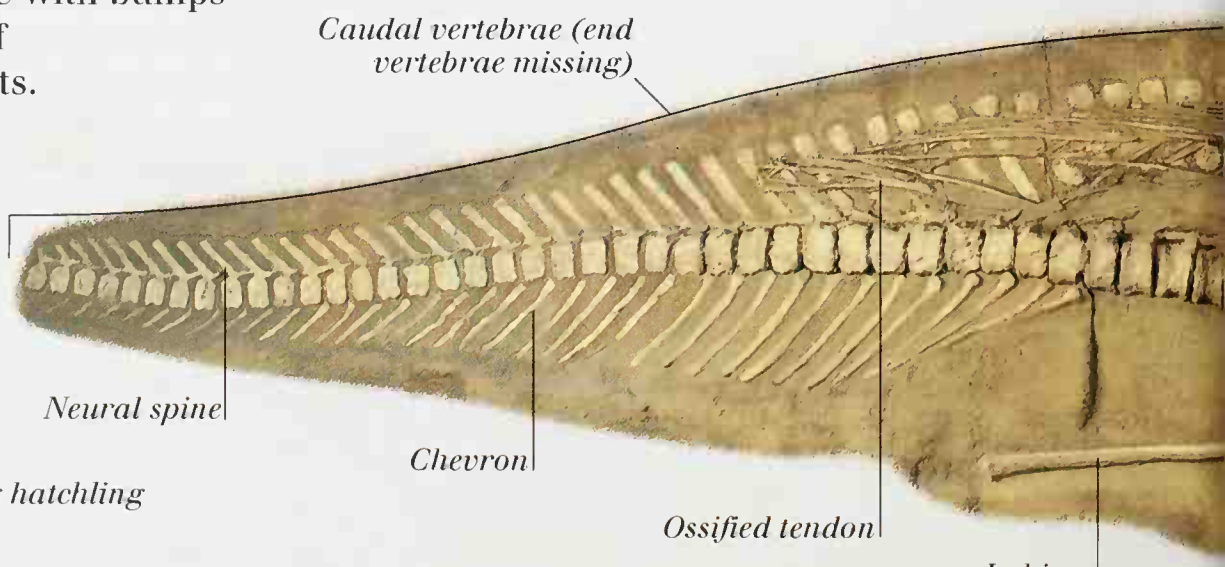
FOSSIL SKELETON OF YOUNG HADROSAUR

HADROSAURS WERE a group of ornithischian (bird-hipped) dinosaurs that lived during Late Cretaceous times (97.5–65 million years ago) in what are now North America, Asia, and Europe. A characteristic feature of these herbivorous (plant-eating) dinosaurs was a beak similar to a duck's bill, which is the reason why hadrosaurs are sometimes known as duckbills. Although the beak was toothless, hadrosaurs had large numbers of cheek teeth – sometimes more than 300 in each jaw – for grinding tough vegetation. Hadrosaurs ranged from 13 ft (4 m) to 49 ft (14.9 m) in length. They walked on all fours but ran on their hind limbs, balancing their heavy bodies with a long, stiffened tail. There were two main subgroups of hadrosaurs: hadrosaurines, such as *Gryposaurus* and *Maiasaura*, and lambeosaurines, such as *Corythosaurus* and *Parasaurolophus*. The main difference between the subgroups was the shape of the skull. Hadrosaurines had flat skulls, some with bumps of solid bone on the snout, while the skulls of lambeosaurines had large, hollow, bony crests.

**SKELETON OF YOUNG MAIASAURA**

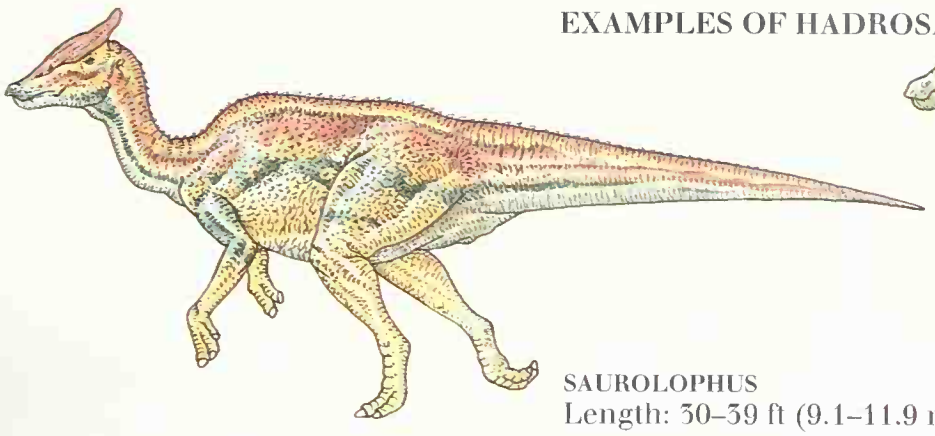



**FOSSIL SKELETON OF GRYPOSAURUS**

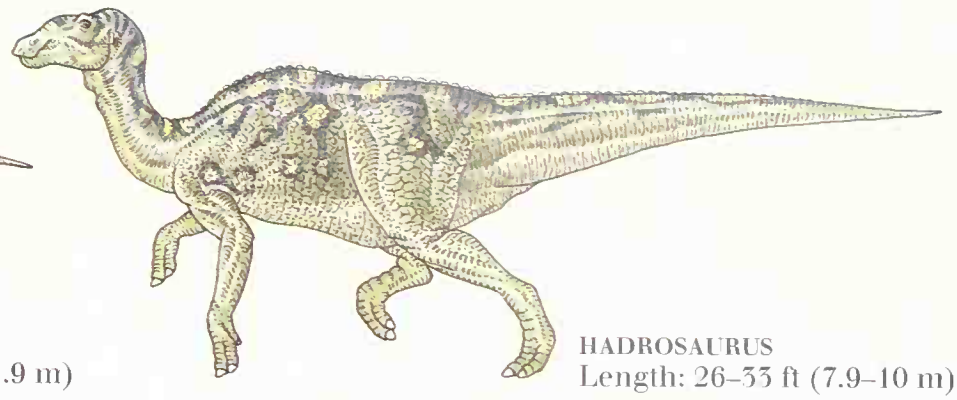



**MODEL OF MAIASAURA NEST**

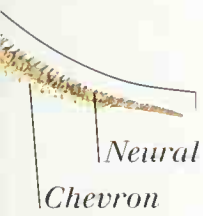
## EXAMPLES OF HADROSAURINES

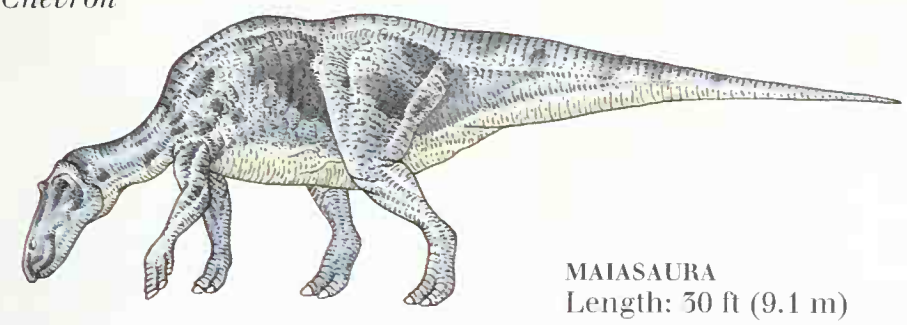


**SAUROLOPHUS**
Length: 30–39 ft (9.1–11.9 m)

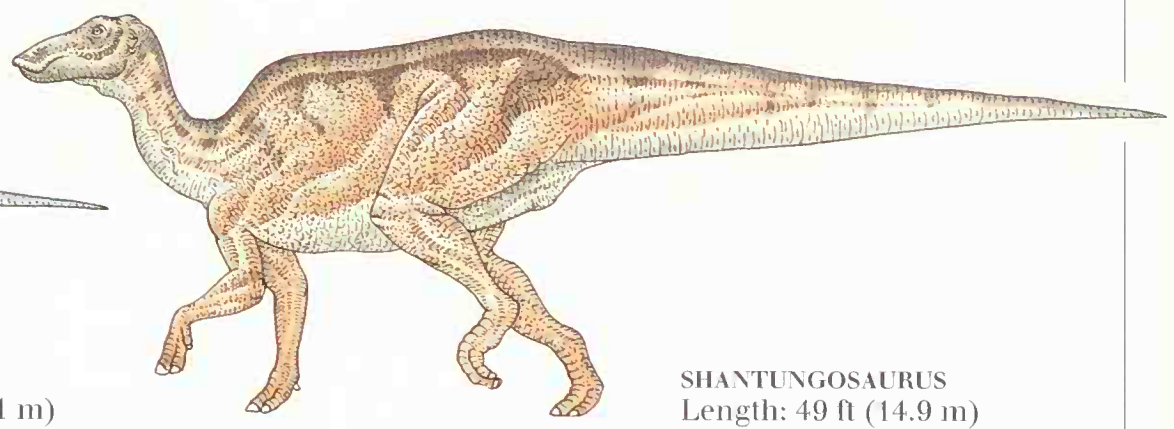


**HADROSAURUS**
Length: 26–33 ft (7.9–10 m)

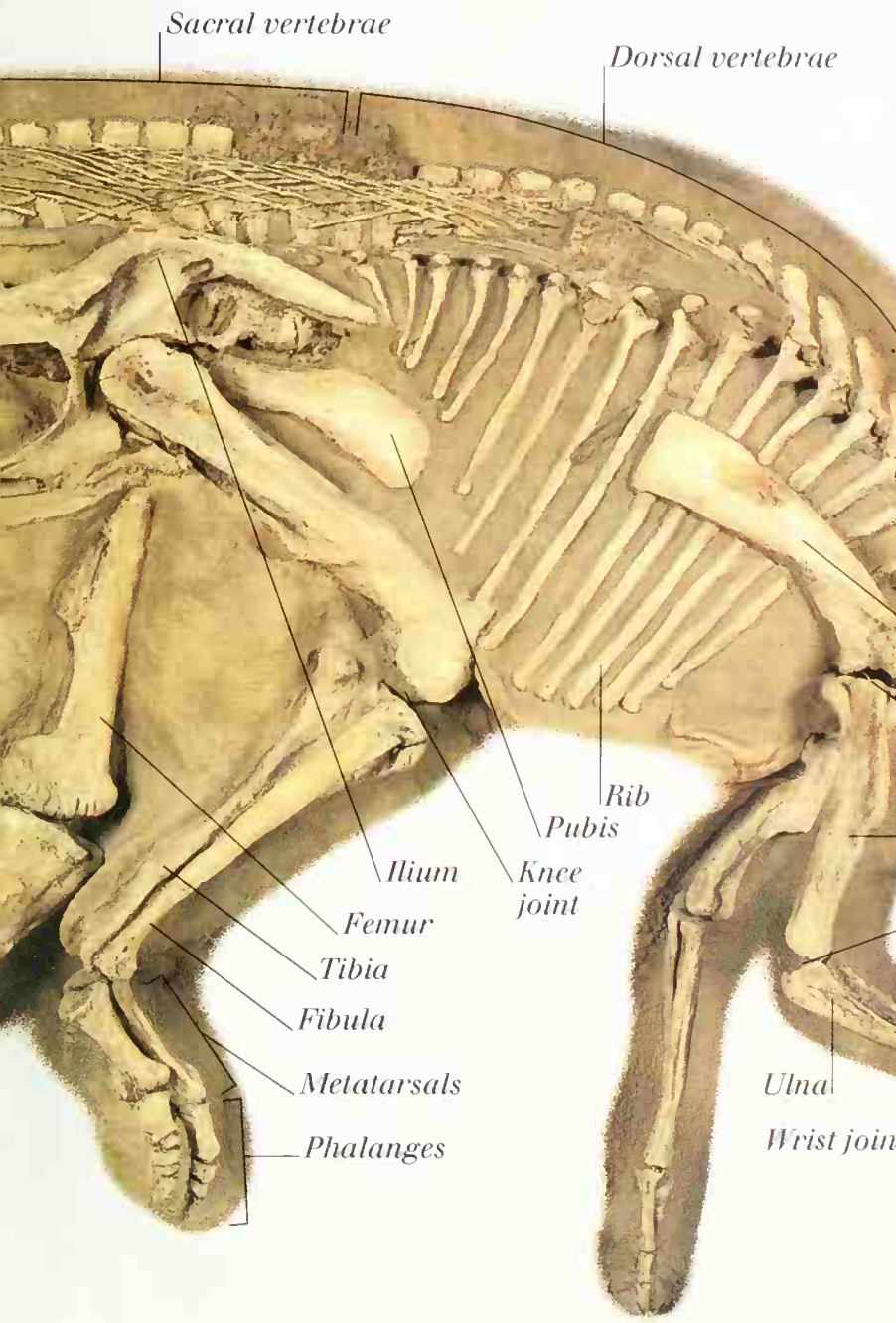


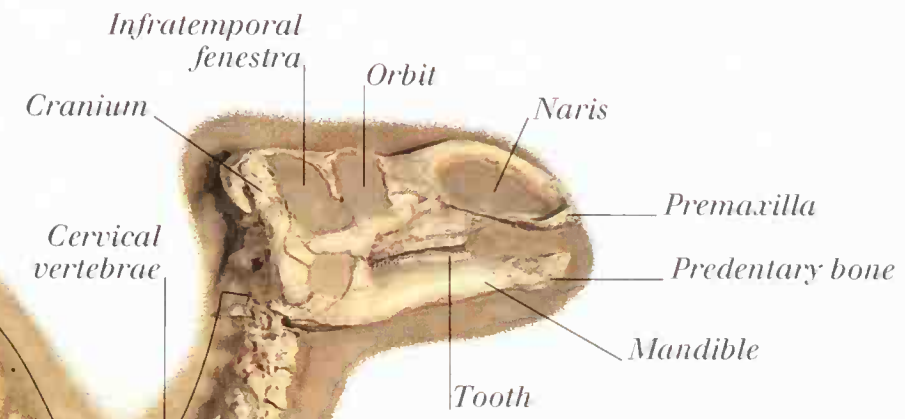



**MAIASAURA**
Length: 30 ft (9.1 m)



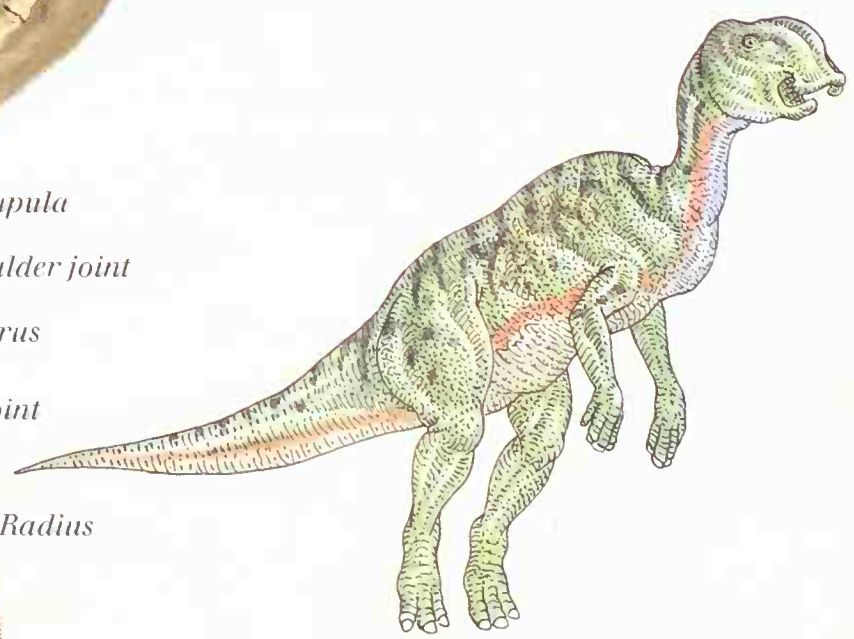
**SHANTUNGOSAURUS**
Length: 49 ft (14.9 m)





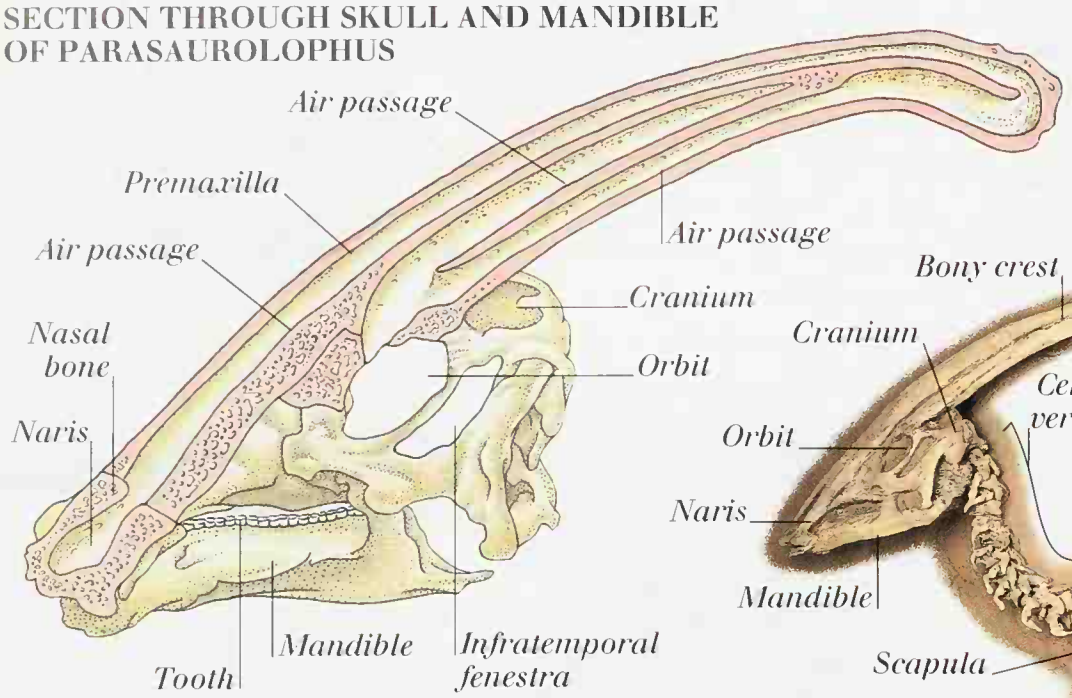




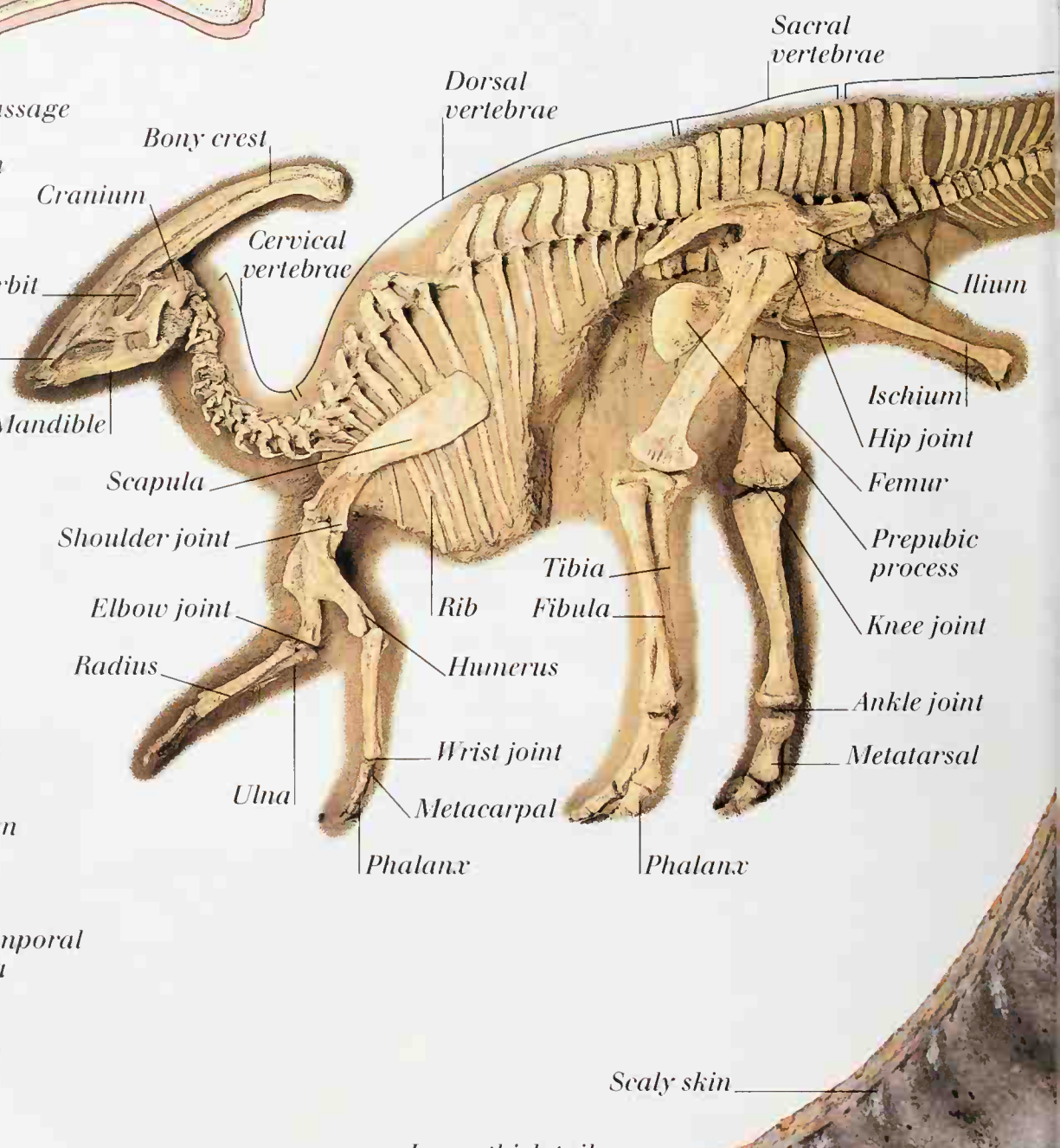
**GRYPOSAURUS**
Length: 26–33 ft (7.9–10 m)

# Hadrosaurs 2

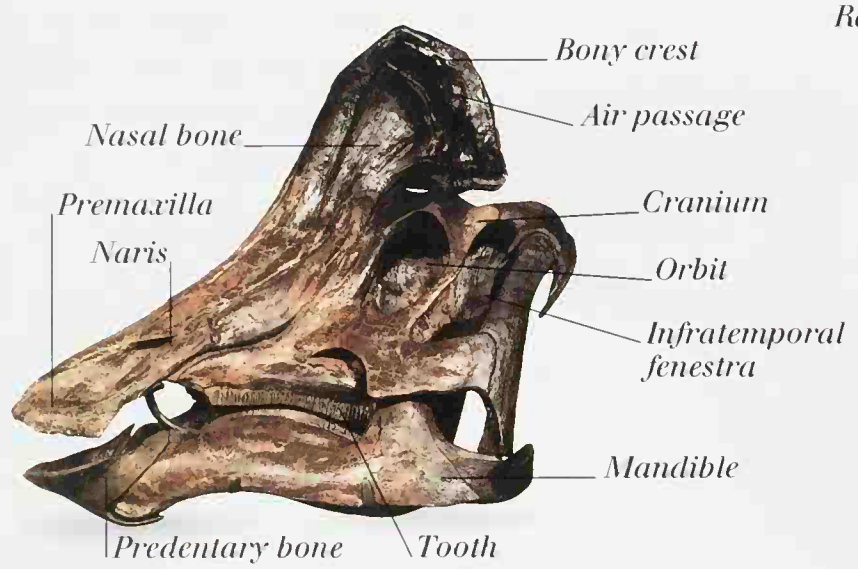
### SECTION THROUGH SKULL AND MANDIBLE OF PARASAUROLOPHUS



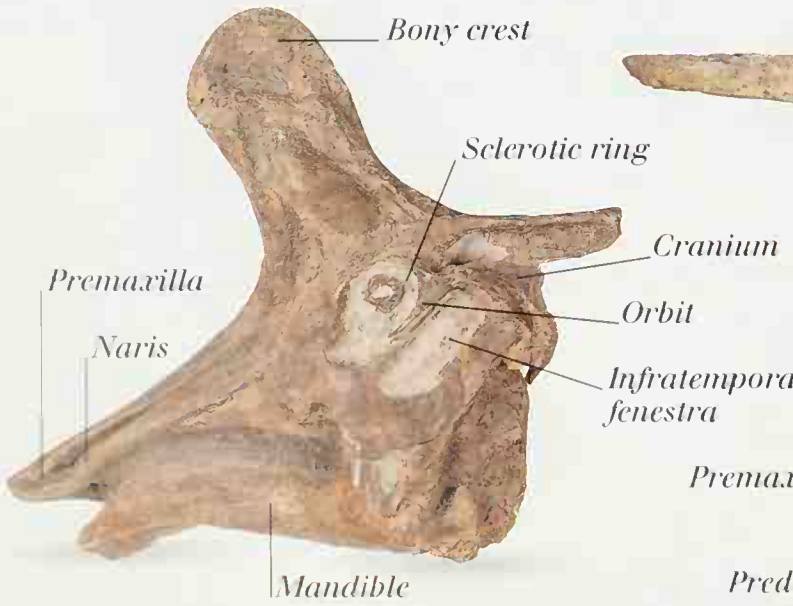

### FOSSIL SKELETON OF PARASAUROLOPHUS



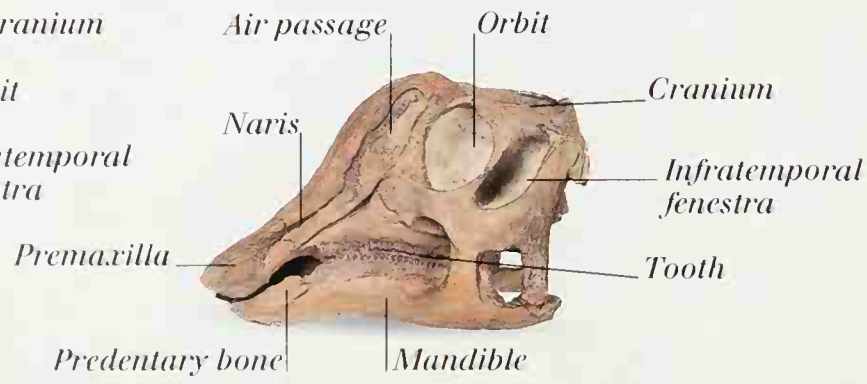

### EXAMPLES OF LAMBEOSAURINE SKULLS




SKULL AND MANDIBLE OF CORYTHOSAURUS




SKULL AND MANDIBLE OF ADULT LAMBEOSAURUS

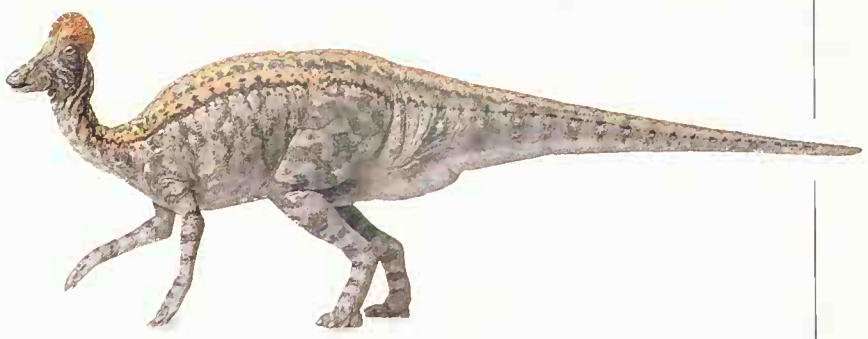



SKULL AND MANDIBLE OF JUVENILE LAMBEOSAURUS

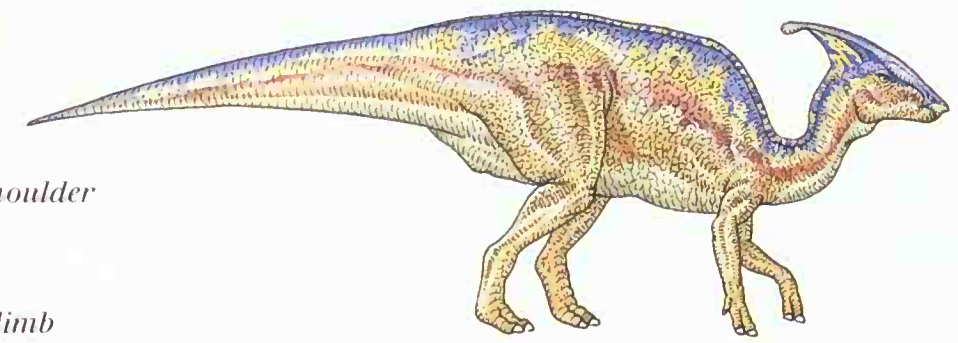
## EXTERNAL FEATURES OF CORYTHOSAURUS

*Bony crest*
*Eye*
*Naris*
*Toothless beak*
*Caudal vertebrae*
*Cheek pouch*
*Neural spine*
*Tongue*
*Chevron*
*Neck*
*Shoulder*
*Forelimb*
*Elbow*
*Wrist*
*Hand*
*Finger*
*Knee*
*Nail*
*Thigh*
*Tubercle*
*Hindlimb*
*Ankle*
*Foot*
*Toe*
*Nail*

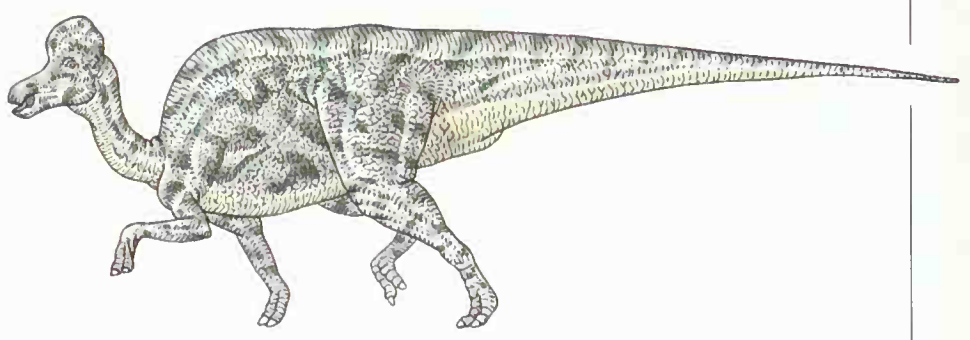
## EXAMPLES OF LAMBEOSAURINES



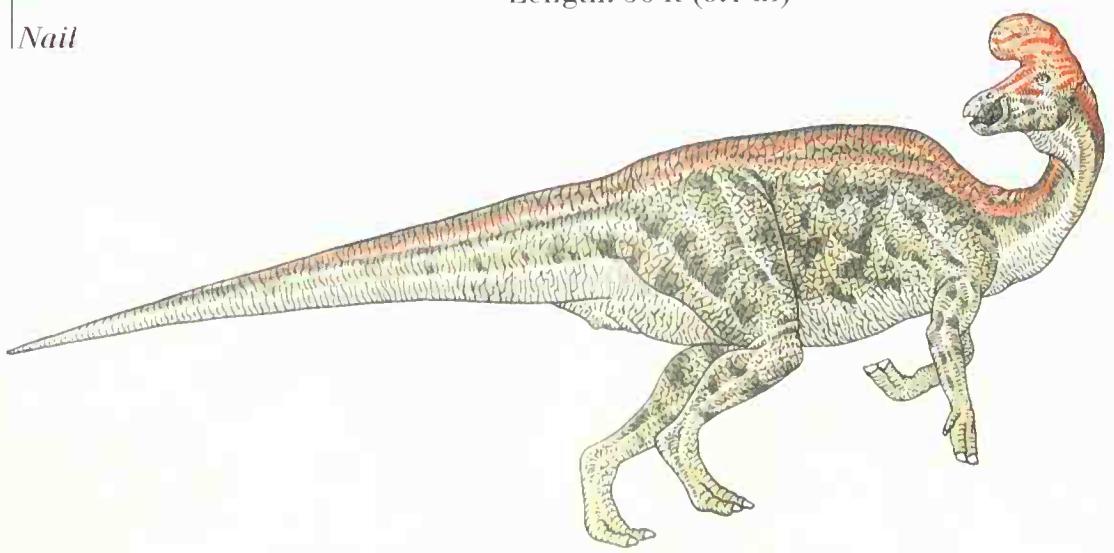
**CORYTHOSAURUS**
Length: 33 ft (10 m)



**PARASAUROLOPHUS**
Length: 33 ft (10 m)



**HYPACROSAURUS**
Length: 30 ft (9.1 m)

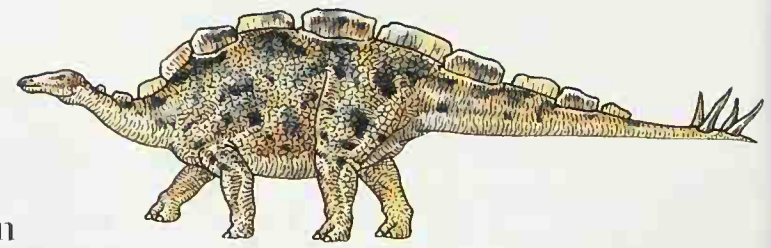


**LAMBEOSAURUS**
Length: 49 ft (14.9 m)

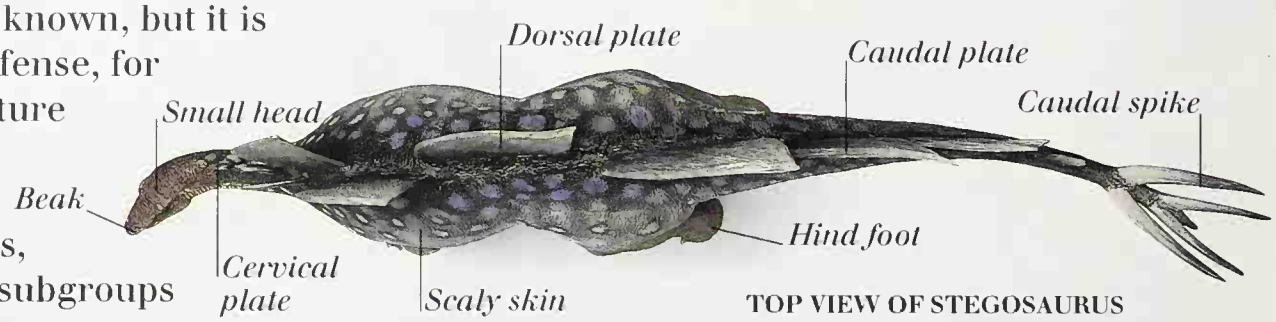
# Stegosaurs

STEGOSAURS WERE A GROUP of ornithischian (bird-hipped) dinosaurs that lived from Middle Jurassic to Early Cretaceous times (188–97.5 million years ago) in what are now North America, Europe, Africa, and Asia. They were medium-size dinosaurs – between about 10 ft (3 m) and 30 ft (9.1 m) long – with bulky bodies that weighed up to about 1.5 tons. The main characteristic of stegosaurs was the two rows of dorsal plates or spines that ran along their backs. The exact function of these plates or spikes is not known, but it is thought that they may have been for defense, for display, or for regulating body temperature by absorbing or radiating heat. Also, probably for defense, stegosaurs had caudal (tail) spikes and, in some species, shoulder spikes. There were two main subgroups of stegosaurs: stegosaurids, such as *Stegosaurus*, *Tuojiangosaurus*, *Kentrosaurus*, and *Wuerhosaurus*, and huayangosaurids. *Huayangosaurus*, the only known huayangosaurid, resembled stegosaurids but is thought to have been more primitive.

**EXAMPLES OF STEGOSAURS**

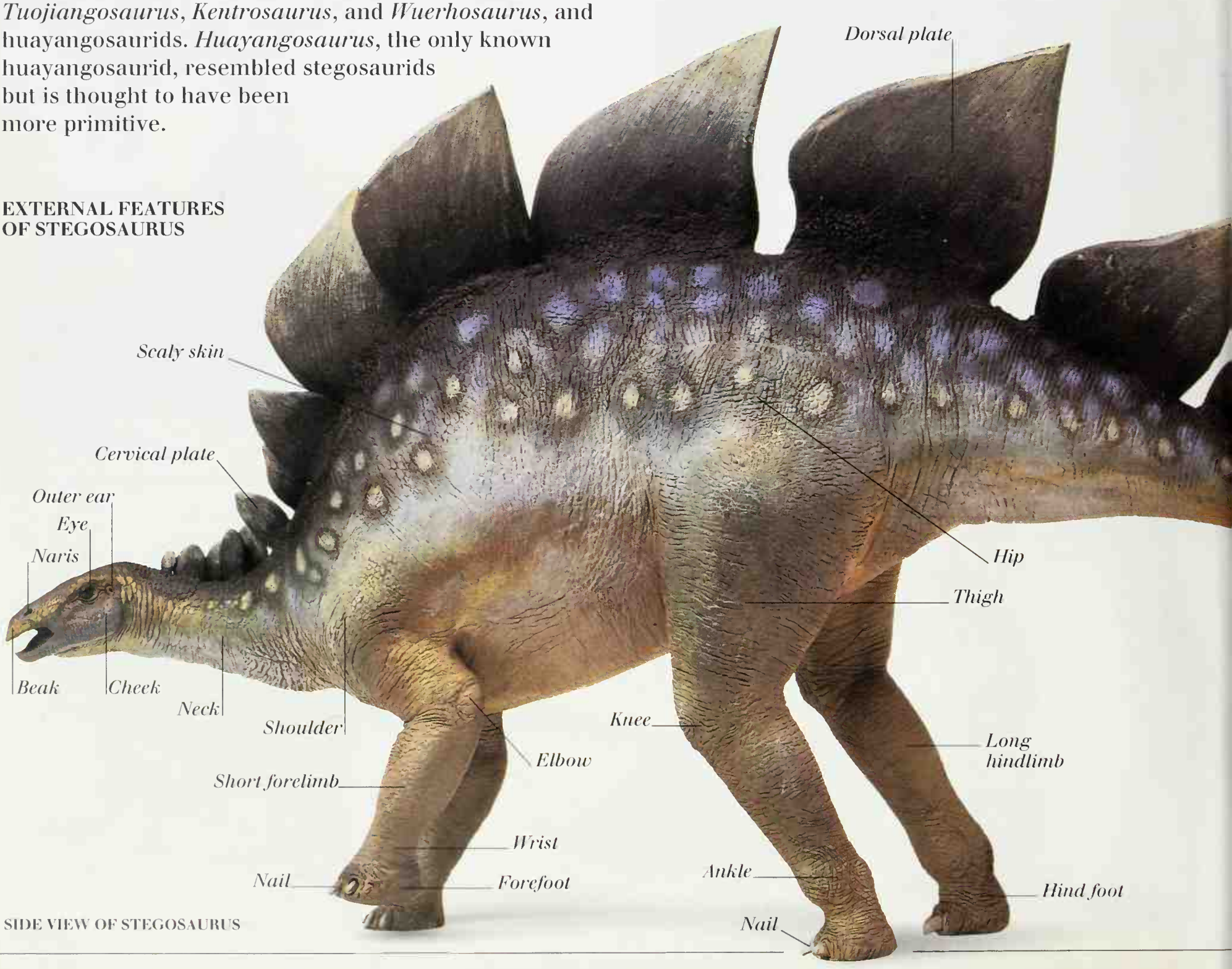


**WUERHOSAURUS**
A stegosaurid
Length: 20 ft (6.1 m)

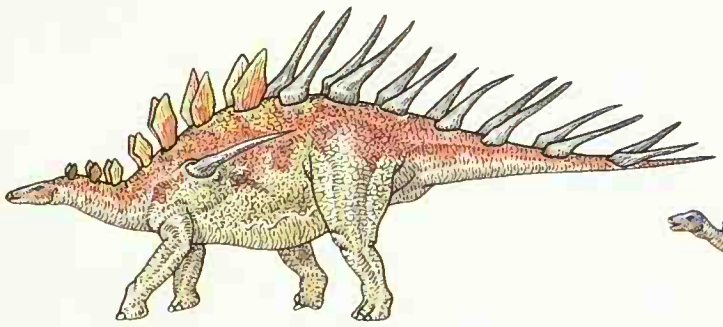



**TOP VIEW OF STEGOSAURUS**

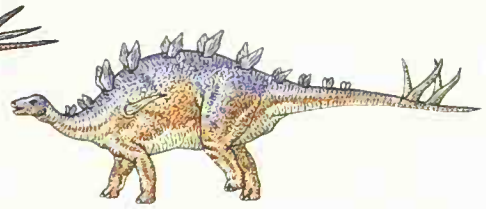
**EXTERNAL FEATURES OF STEGOSAURUS**



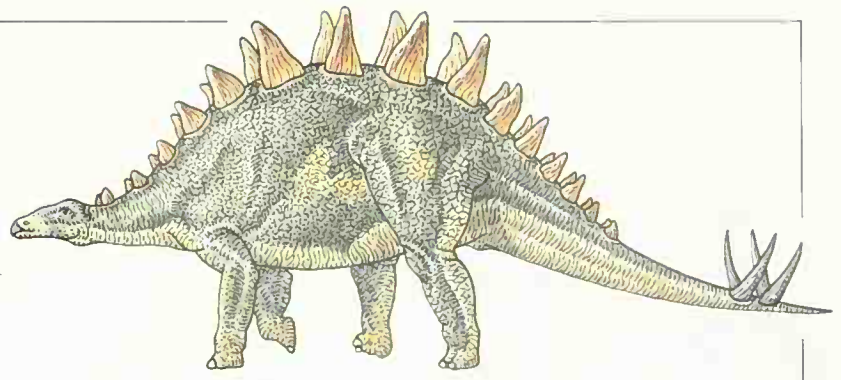

**SIDE VIEW OF STEGOSAURUS**



**KENTROSAURUS**
A stegosaurid
Length: 16 ft (4.9 m)

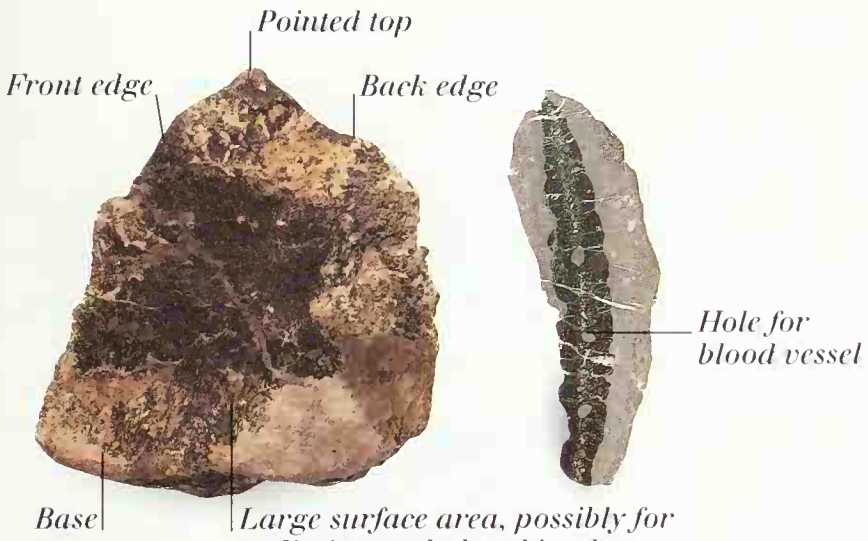


**HUAYANGOSAURUS**
A huayangosaurid
Length: 13 ft (4 m)



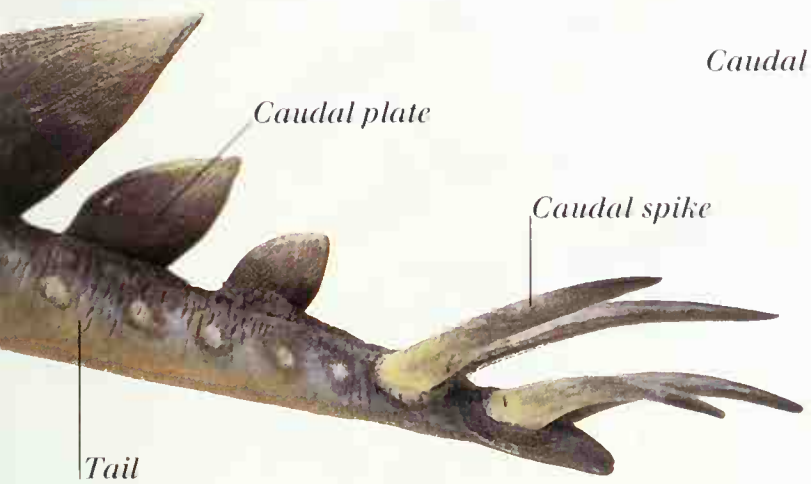
**TUOJIANGOSAURUS**
A stegosaurid
Length: 23 ft (7 m)

## DORSAL PLATE OF STEGOSAURUS

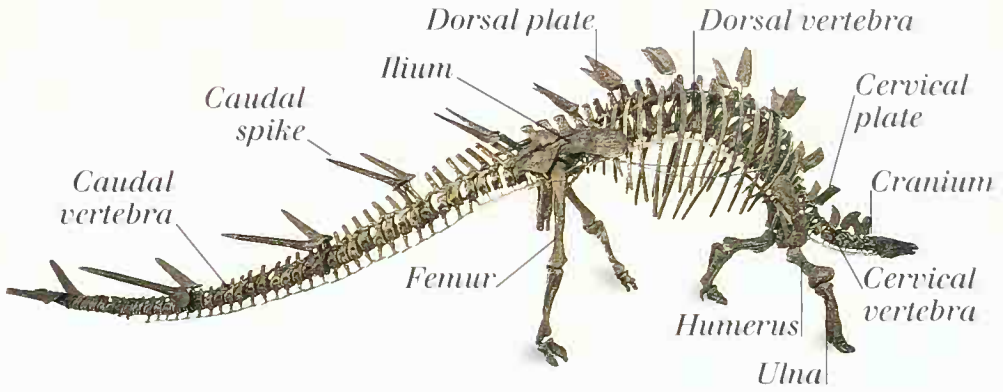



SIDE VIEW OF DORSAL PLATE

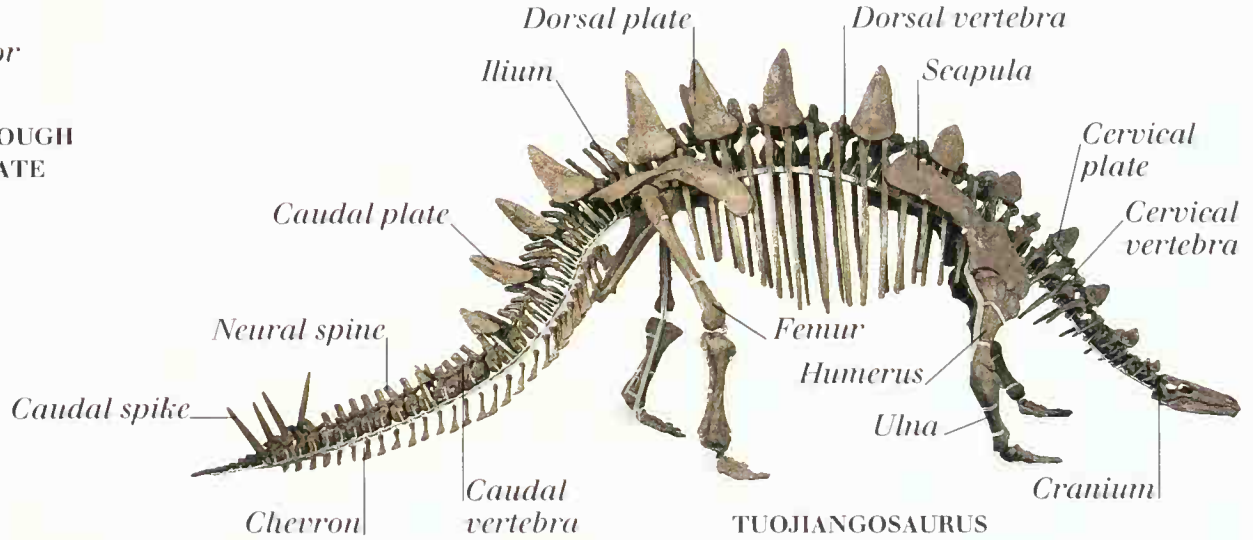
SECTION THROUGH DORSAL PLATE



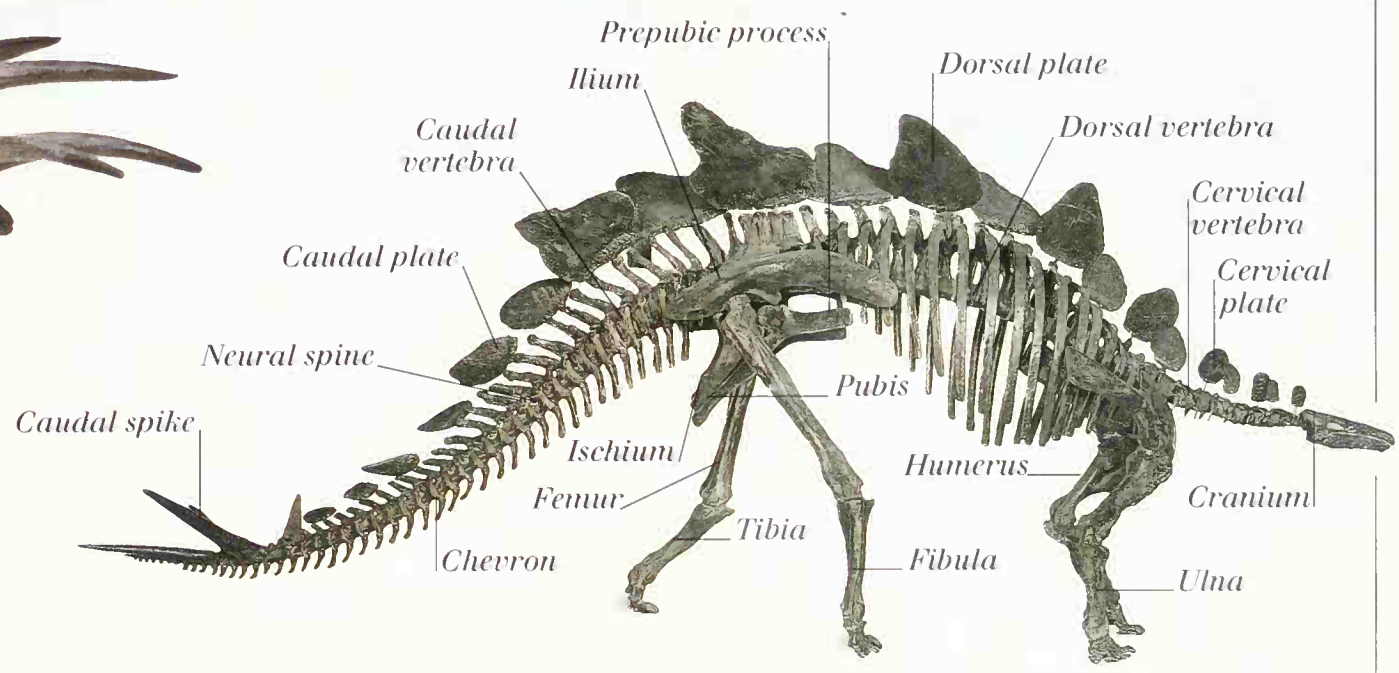

## EXAMPLES OF STEGOSAUR SKELETONS




KENTROSAURUS




TUOJIANGOSAURUS




STEGOSAURUS

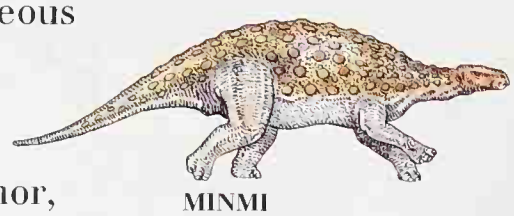
# Ankylosaurs

SHOULDER SPIKE OF POLACANTHUS

ANKYLOSAURS WERE A GROUP OF HERBIVOROUS (plant-eating), ornithischian (bird-hipped) dinosaurs that lived from Middle Jurassic to Late Cretaceous times (188–65 million years ago) in what are now Mongolia, North America, Antarctica, Australia, and Europe. They ranged from 8 ft (2.4 m) to 35 ft (10.7 m) long, and weighed up to 2 tons.

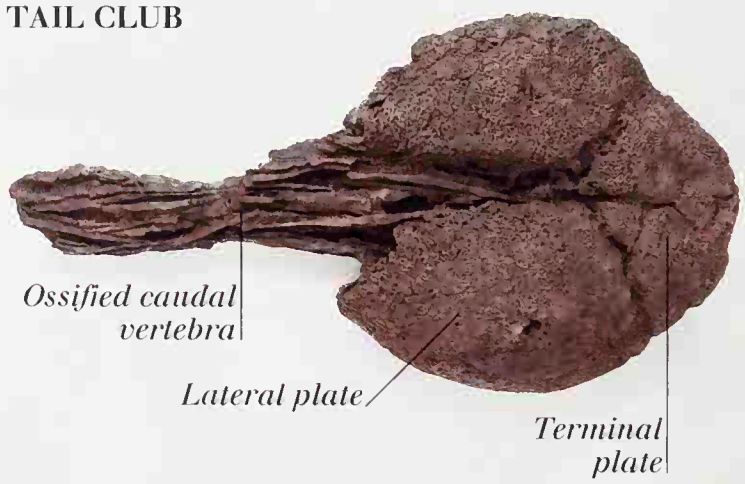
The most notable feature of these dinosaurs was their heavy armor, which consisted of bony studs, plates, and spikes that protected them from predators. Ankylosaurs also had characteristics typical of herbivorous dinosaurs: toothless beaks and cheek teeth, for cropping and chewing vegetation. It is possible that ankylosaurs also had a gizzard (muscular stomach) and gastroliths (stones) for further breaking down plant material in the gut. There were two main subgroups of ankylosaurs: ankylosaurids, such as *Ankylosaurus*, *Euoplocephalus*, and *Pinacosaurus*; and nodosaurids, such as *Edmontonia*, *Minmi*, *Panoplosaurus*, and *Polacanthus*. The most apparent differences between the subgroups were that ankylosaurids had horns on their head and a bony tail club, while nodosaurids tended to have neither.

**EXAMPLES OF ANKYLOSAURS**

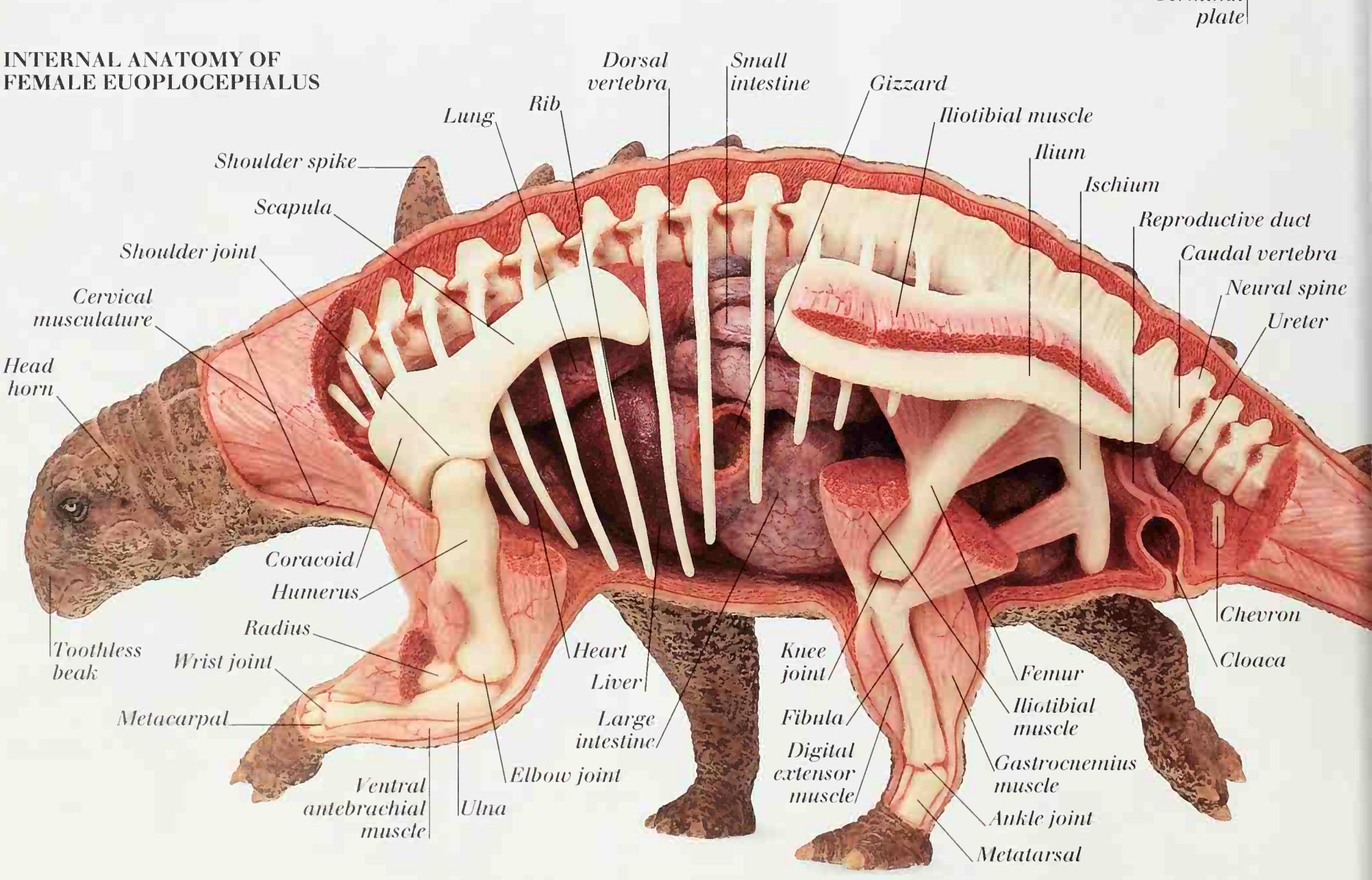


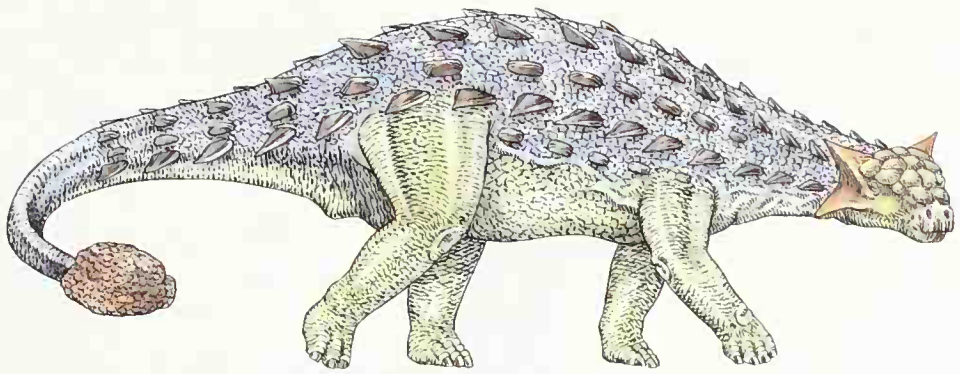
**MINMI**
A nodosaurid
Length: 8 ft (2.4 m)

**FOSSIL OF ANKYLOSAURUS TAIL CLUB**

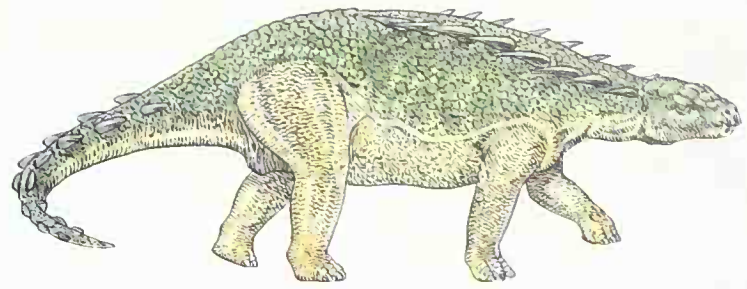



**INTERNAL ANATOMY OF FEMALE EUOPLOCEPHALUS**



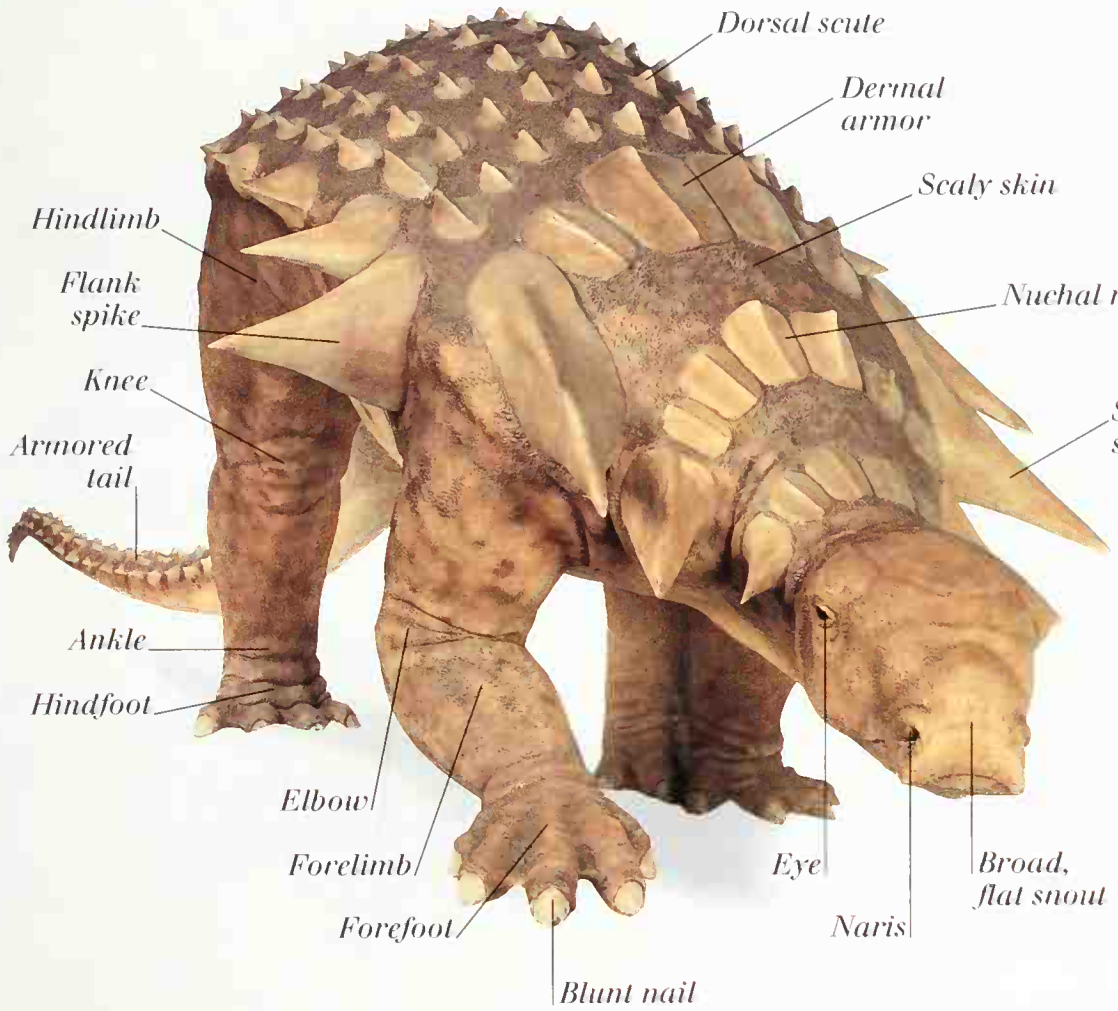


**PINACOSAURUS**
An ankylosaurid
Length: 16 ft 6 in (5 m)

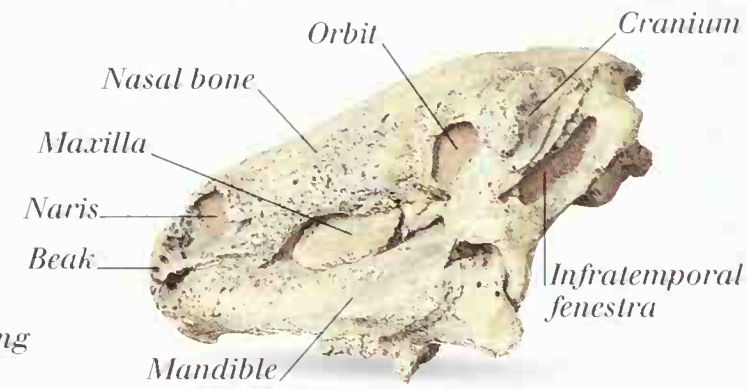


**POLACANTHUS**
A nodosaurid
Length: 13 ft (4 m)

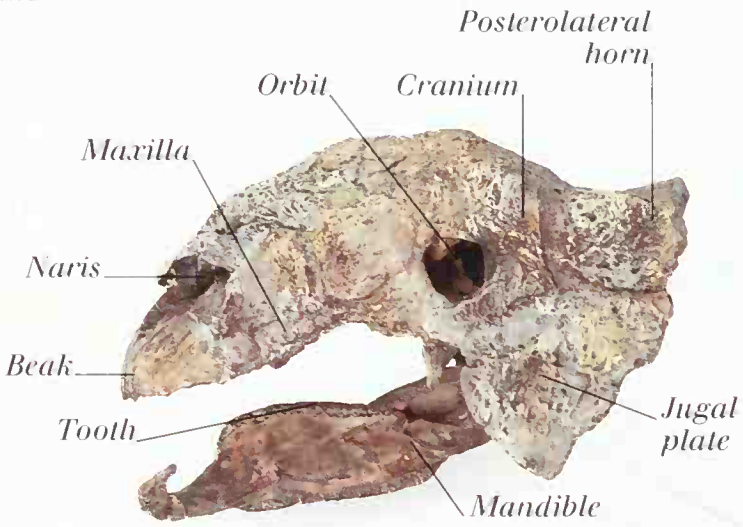
## EXTERNAL FEATURES OF EDMONTONIA



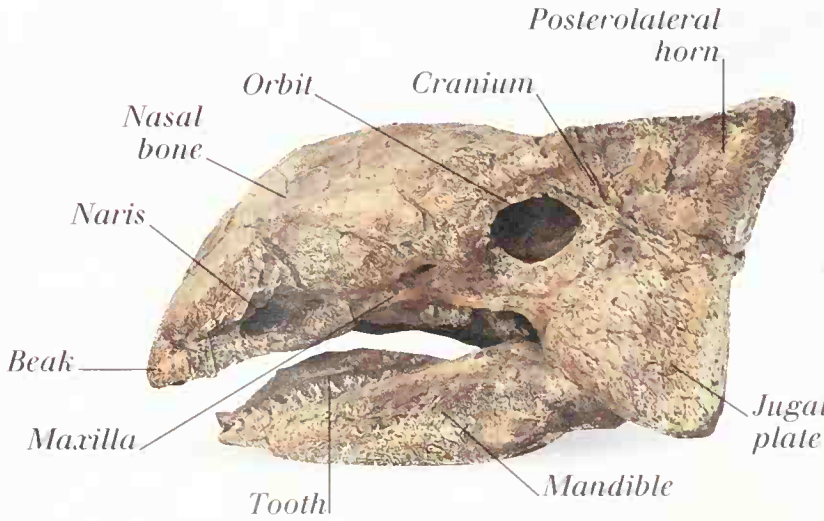

## EXAMPLES OF ANKYLOSAUR SKULLS




**SKULL AND MANDIBLE OF PANOPLOSAURUS**




**SKULL AND MANDIBLE OF EUOPLOCEPHALUS**

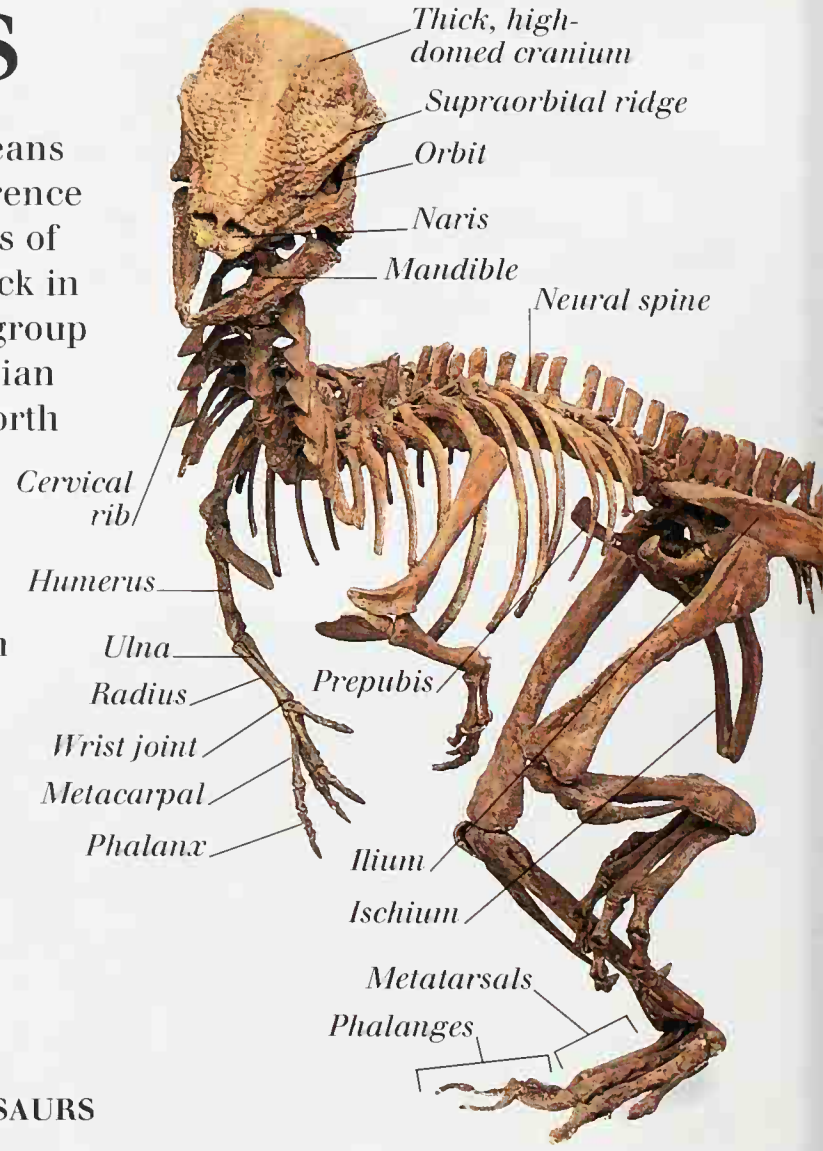



**SKULL AND MANDIBLE OF ANKYLOSAURUS**

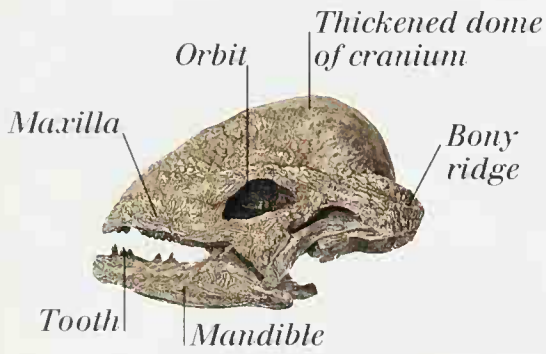
# Pachycephalosaurs

HEAD-BUTTING PRENOCEPHALES

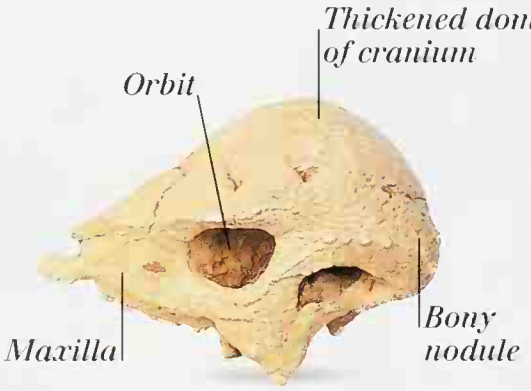
THE TERM "pachycephalosaur" means "thick-headed lizard," a reference to the extremely thick-roofed skulls of these dinosaurs – up to 10 in (25 cm) thick in some cases. Pachycephalosaurs were a group of herbivorous (plant-eating), ornithischian (bird-hipped) dinosaurs that lived predominantly in what are now North America, Madagascar, China, and Mongolia in Late Cretaceous times (97.5–65 million years ago). Their thick skulls were probably designed to protect their brains during head-butting contests to win territory and mates; their hips and spine were also strengthened to withstand the shock of head-butting. Pachycephalosaurs ranged from about 20 in (50 cm) to 15 ft (4.6 m) in length. They had short arms, long, stiff tails to aid balance, and thickset bodies. There were two main subgroups of pachycephalosaurs: pachycephalosaurids, such as *Pachycephalosaurus, Stegoceras,* and *Prenocephale,* and homalocephalids, such as *Homalocephale* and *Wannanosaurus.* Pachycephalosaurids had thick, high-domed skulls that could withstand heavier blows than the less thick, flat-topped skulls of homalocephalids.



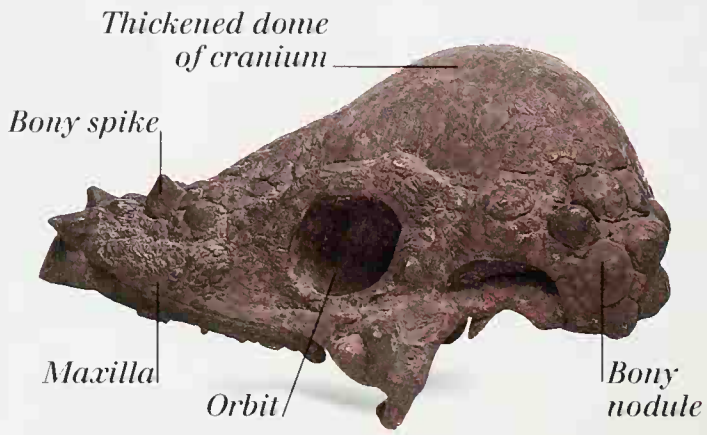

## EXAMPLES OF SKULLS OF PACHYCEPHALOSAURS




SKULL AND MANDIBLE OF STEGOCERAS

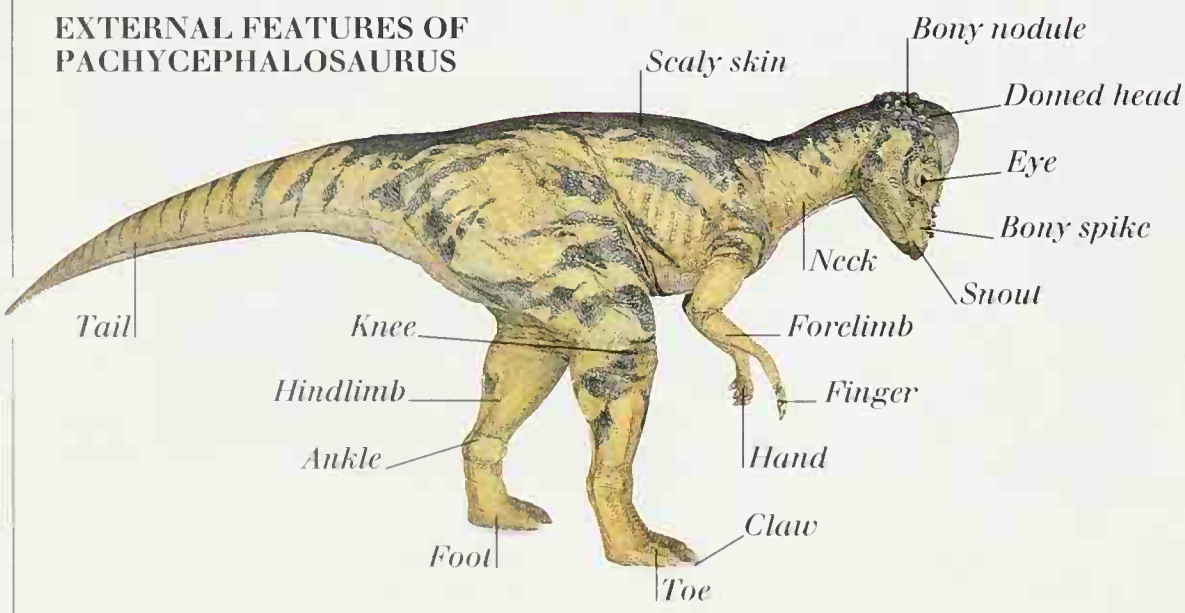


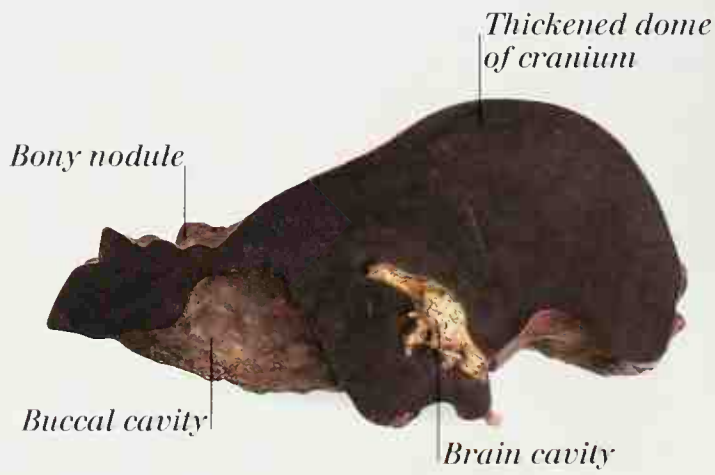

SKULL OF PRENOCEPHALE




SKULL OF PACHYCEPHALOSAURUS

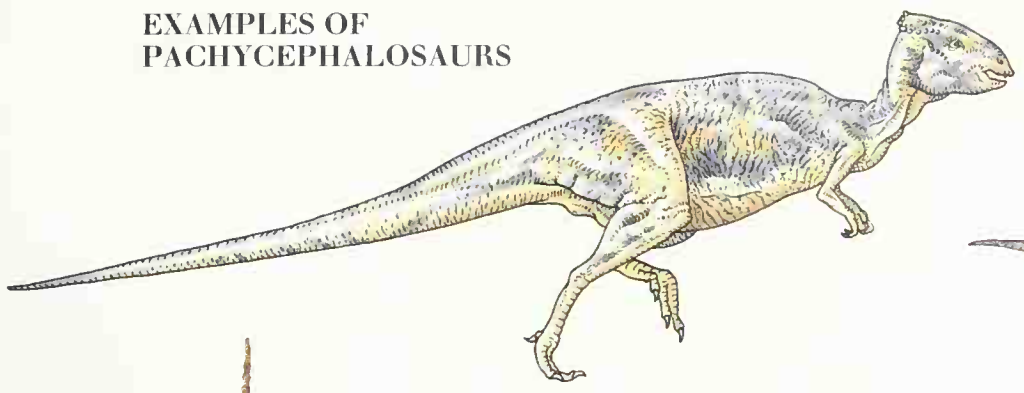
## EXTERNAL FEATURES OF PACHYCEPHALOSAURUS



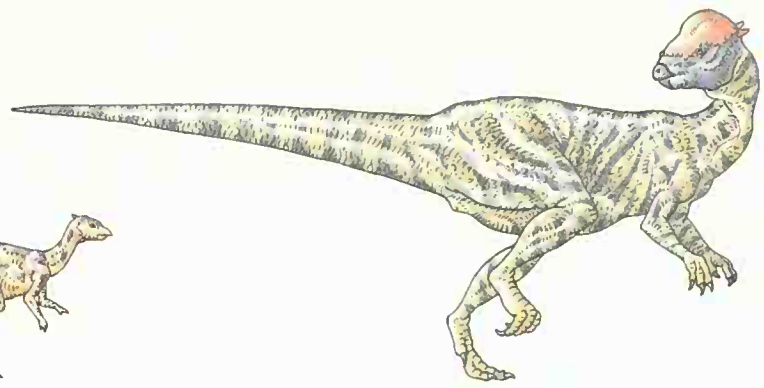

SECTION THROUGH SKULL OF PACHYCEPHALOSAURUS

## EXAMPLES OF PACHYCEPHALOSAURS



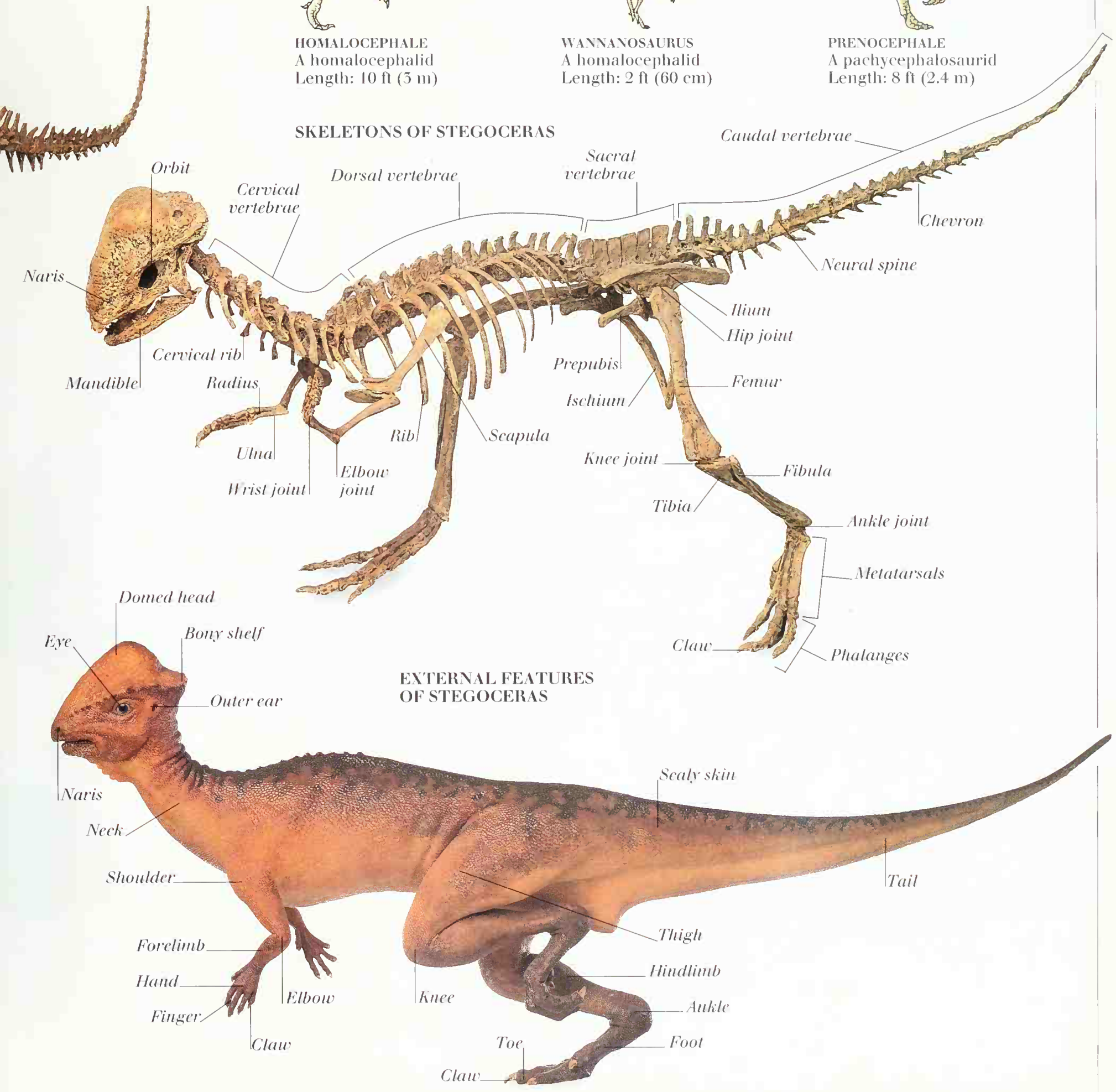
**HOMALOCEPHALE**
A homalocephalid
Length: 10 ft (3 m)

**WANNANOSAURUS**
A homalocephalid
Length: 2 ft (60 cm)



**PRENOCEPHALE**
A pachycephalosaurid
Length: 8 ft (2.4 m)

## SKELETONS OF STEGOCERAS



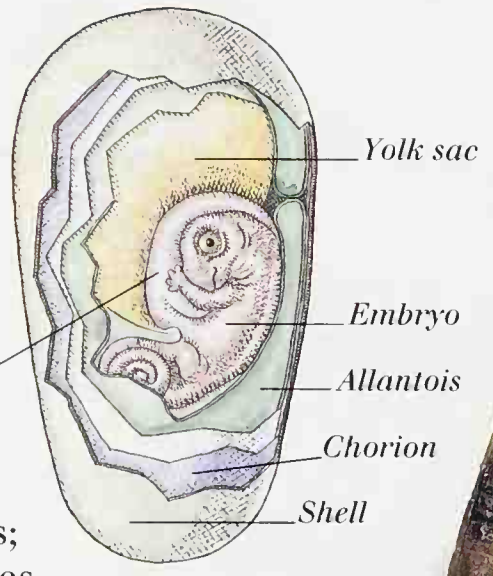

## EXTERNAL FEATURES OF STEGOCERAS

# Ceratopsians 1

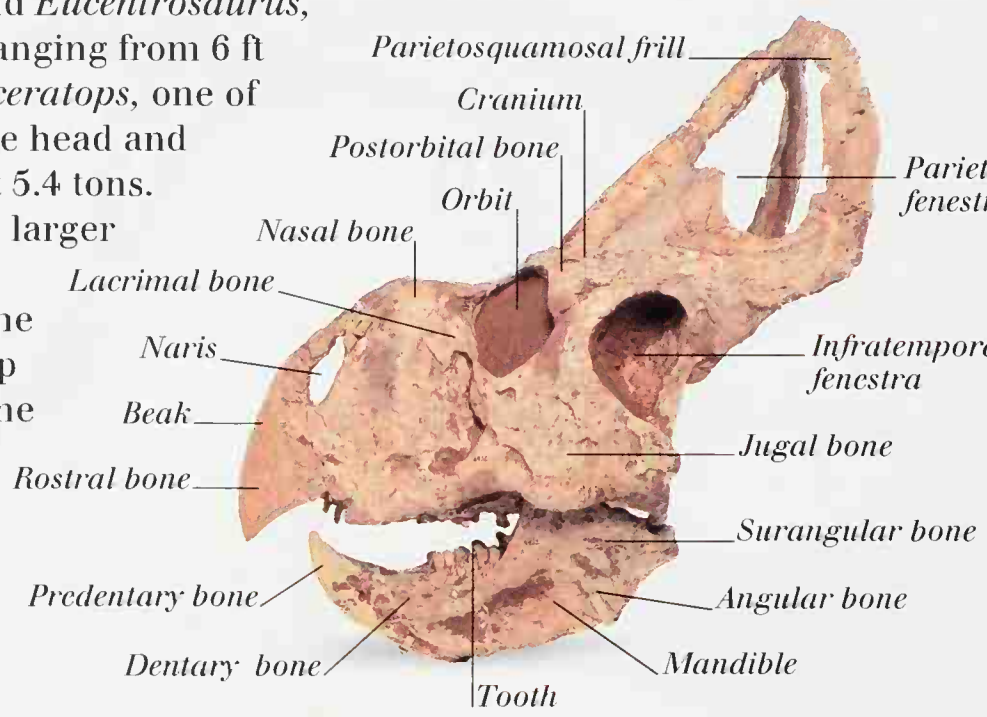
NEST AND EGGS OF PROTOCERATOPS

CERATOPSIANS WERE A GROUP of ornithischian (bird-hipped), herbivorous (plant-eating) dinosaurs with short, deep, parrot-like beaks. These dinosaurs flourished during the Cretaceous period (144–65 million years ago). There were three subgroups of ceratopsians: protoceratopsids, ceratopsids, and psittacosaurids. Protoceratopsids, such as *Protoceratops*, *Bagaceratops*, and *Microceratops*, were relatively small, ranging from 30 in (76 cm) to 10 ft (3 m) long. They had a bony frill around the neck that may have been used to frighten predators, protect the neck, or attract mates; the frill may also have served as an anchor for the jaw muscles. Some species of protoceratopsid also had brow ridges and small horns on their noses and cheeks. Ceratopsids, such as *Triceratops*, *Torosaurus*, *Styracosaurus*, *Pachyrhinosaurus*, and *Eucentrosaurus*, were larger than protoceratopsids, ranging from 6 ft (1.8 m) to 30 ft (9.1 m) in length. *Triceratops*, one of the largest ceratopsids, had a massive head and bulky body, and weighed up to about 5.4 tons. Ceratopsids had neck frills that were larger than those of protoceratopsids, and horns on their brow and nose. In some cases, ceratopsid brow horns were up to 3 ft (90 cm) long. *Psittacosaurus*, the only psittacosaurid known, was 6 ft 6 in (2 m) long. In addition to the parrot-like ceratopsian beak, it had small cheek horns; however, it did not have a bony neck frill.

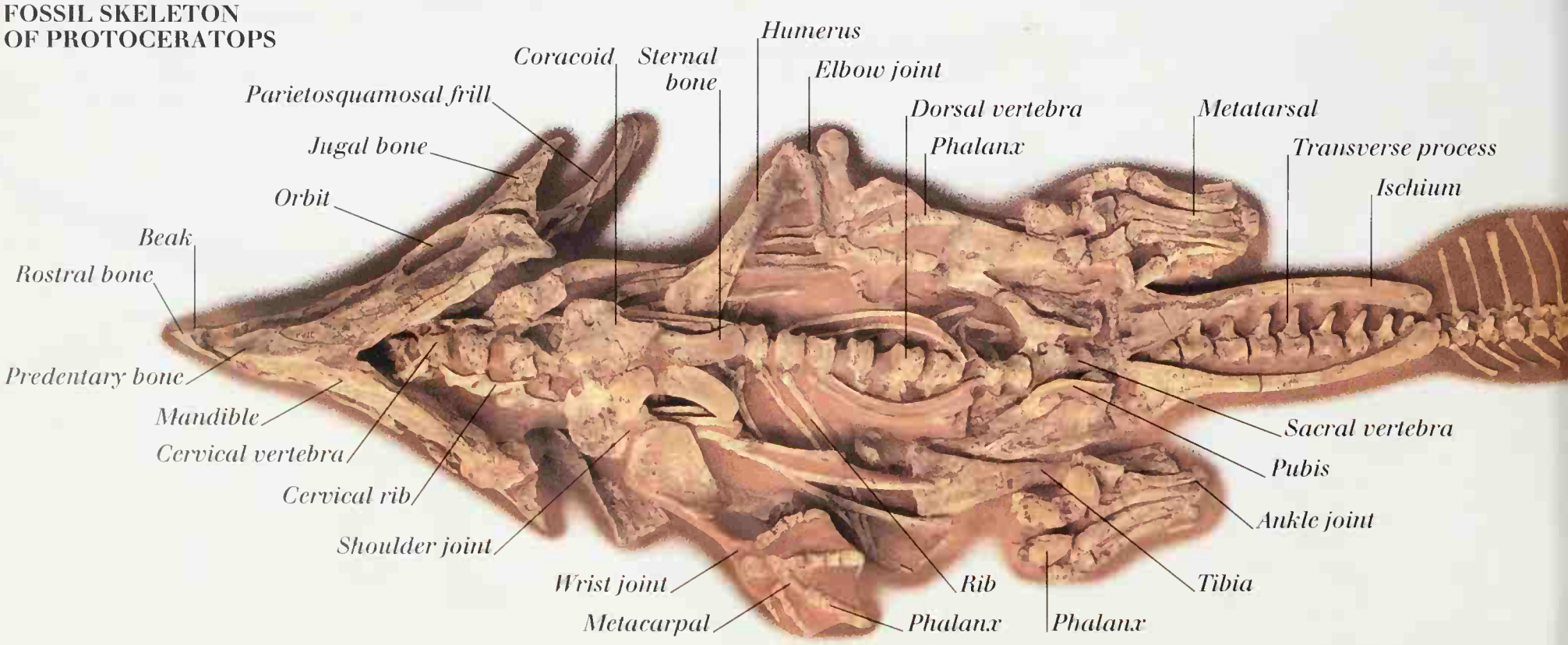
**SECTION THROUGH CERATOPSIAN EGG**




**SKULL AND MANDIBLE OF PROTOCERATOPS**



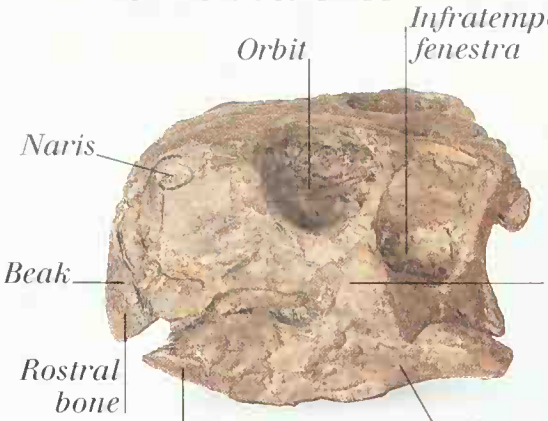
**FOSSIL SKELETON OF PROTOCERATOPS**



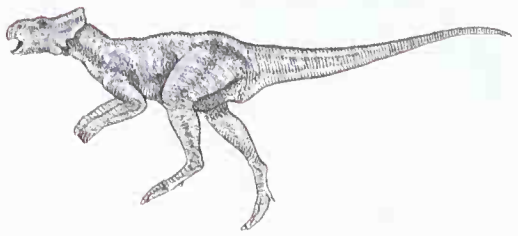
## EXTERNAL FEATURES OF PSITTACOSAURUS

*Eye*
*Outer ear*
*Cheek horn*
*Beak*
*Claw*
*Finger*
*Forelimb*
*Claw*
*Elbow*
*Knee*
*Toe*
*Ankle*
*Hindlimb*
*Thigh*
*Caudal vertebra*
*Chevron*
*Neural spine*

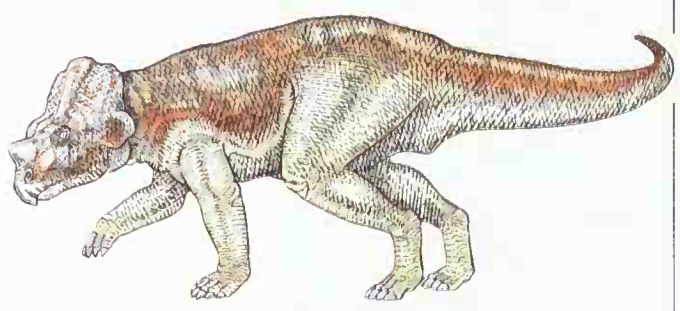
## SKULL AND MANDIBLE OF PSITTACOSAURUS



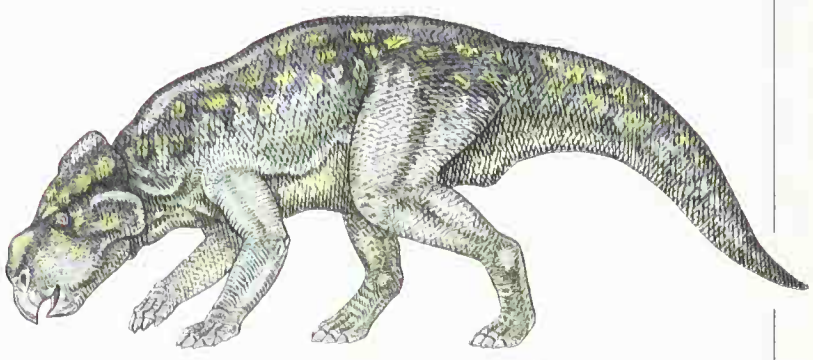

## EXAMPLES OF PROTOCERATOPSIDS



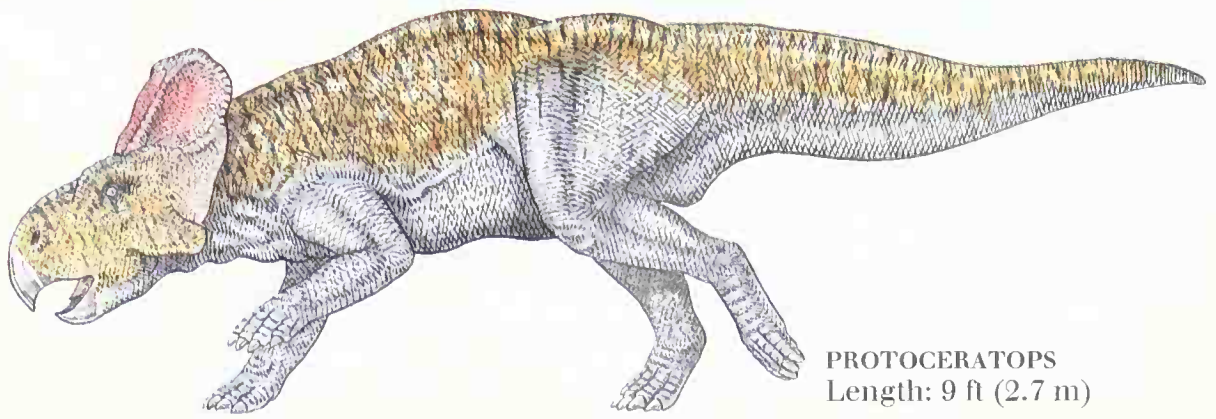
MICROCERATOPS
Length: 30 in (76 cm)



BAGACERATOPS
Length: 3 ft 3 in (1 m)



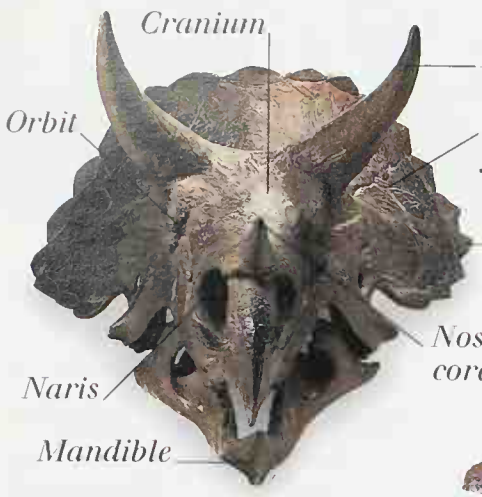
LEPTOCERATOPS
Length: 7 ft (2.1 m)



PROTOCERATOPS
Length: 9 ft (2.7 m)

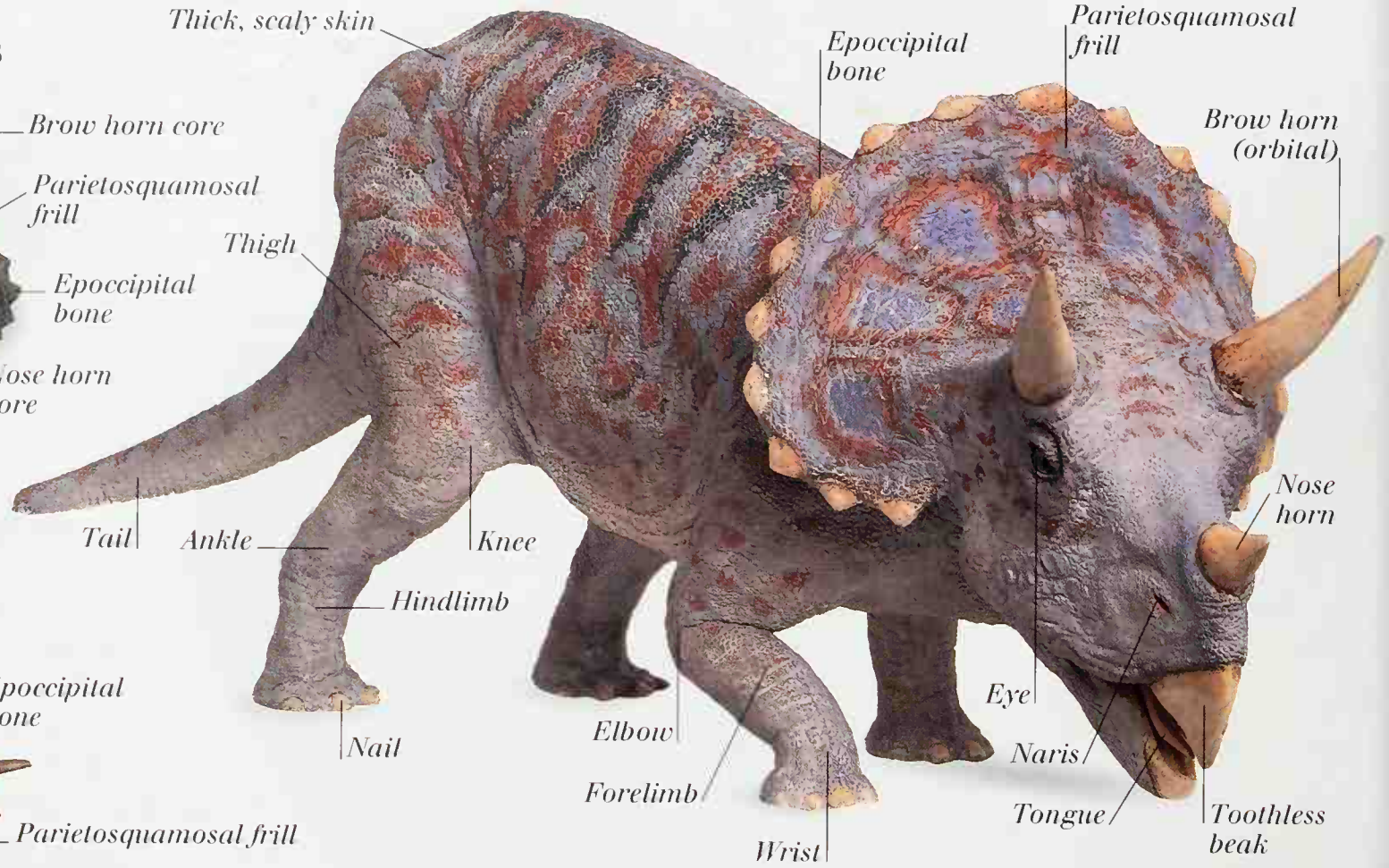
# Ceratopsians 2

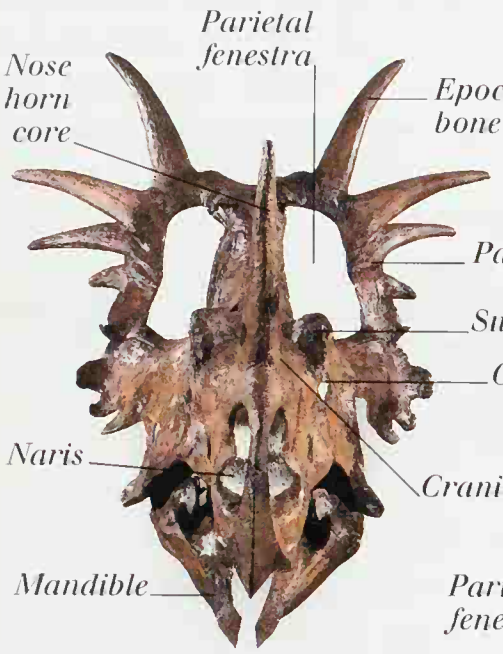
## EXAMPLES OF CERATOPSIAN SKULLS



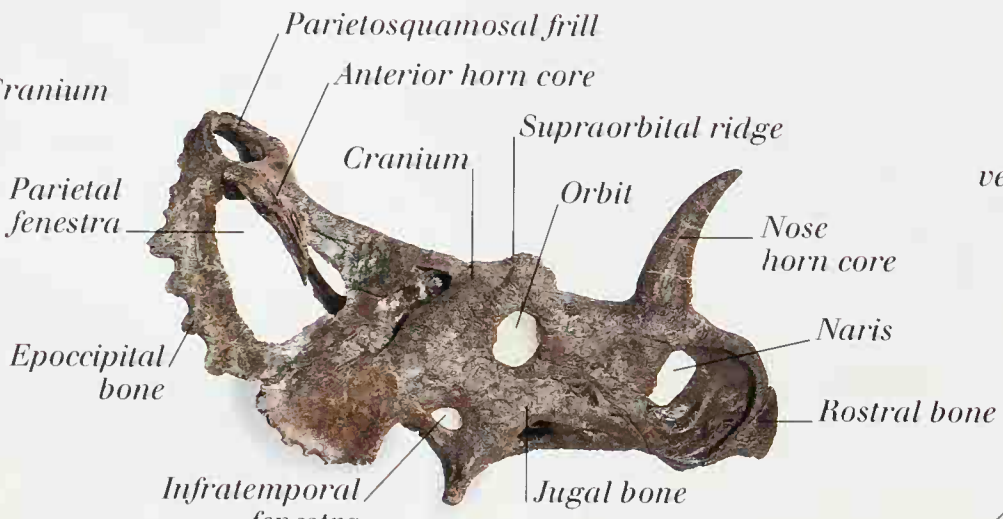

SKULL AND MANDIBLE OF TRICERATOPS

## EXTERNAL FEATURES OF TRICERATOPS

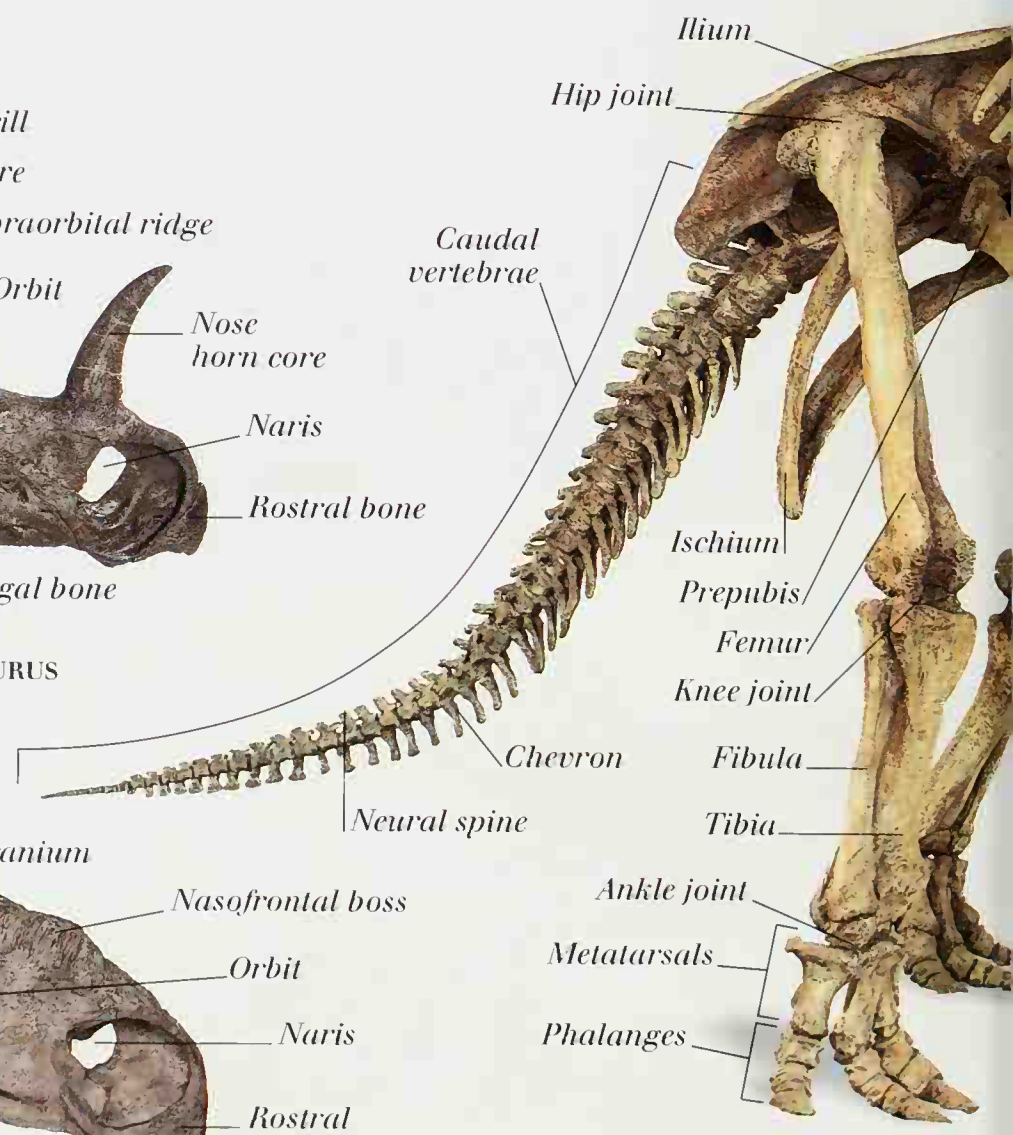


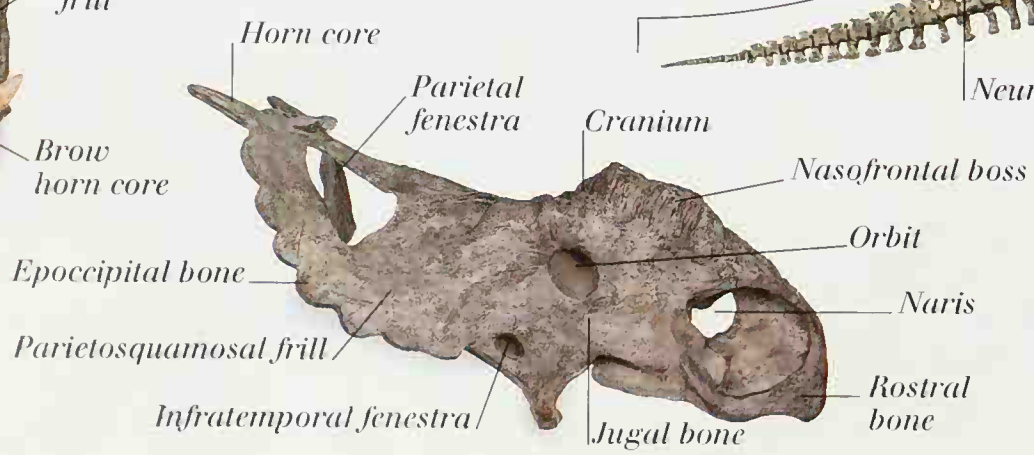

SKULL AND MANDIBLE OF STYRACOSAURUS




SKULL OF EUCENTROSAURUS

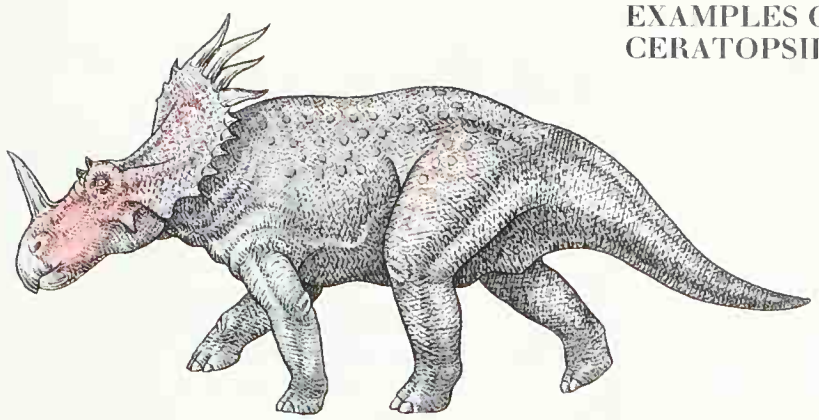


SKULL OF CHASMOSAURUS

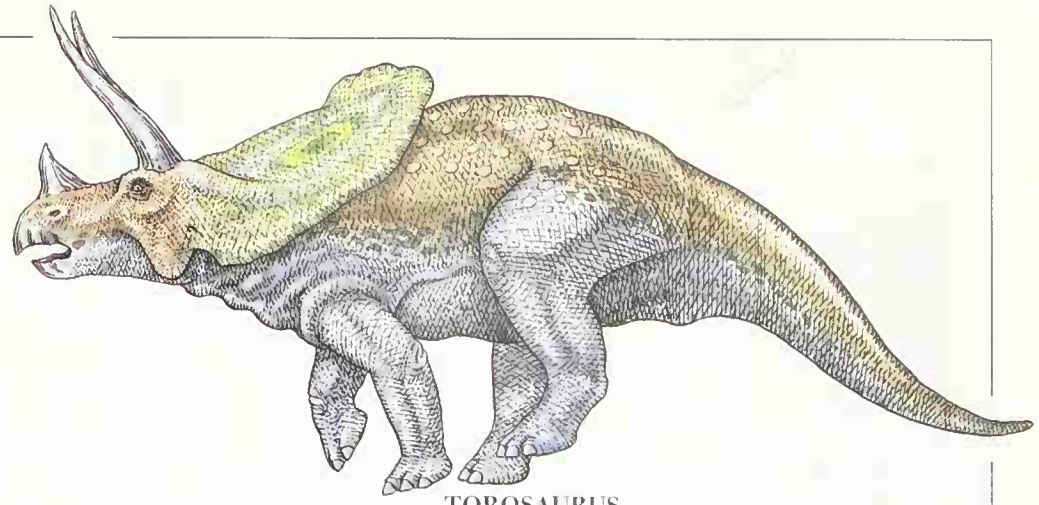



SKULL OF PACHYRHINOSAURUS

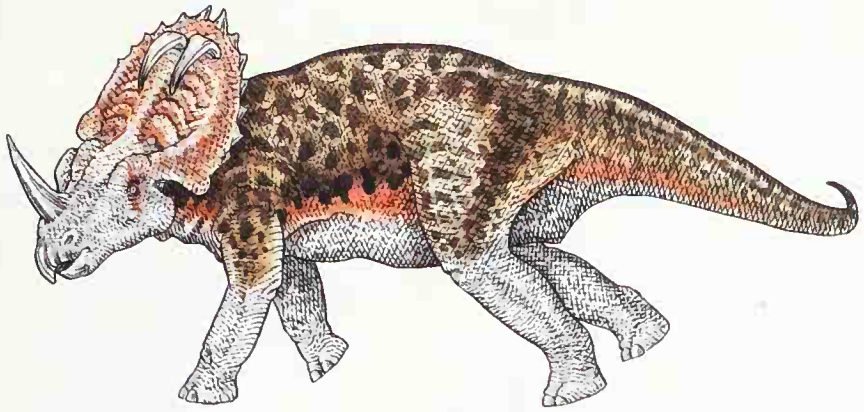
## EXAMPLES OF CERATOPSIDS



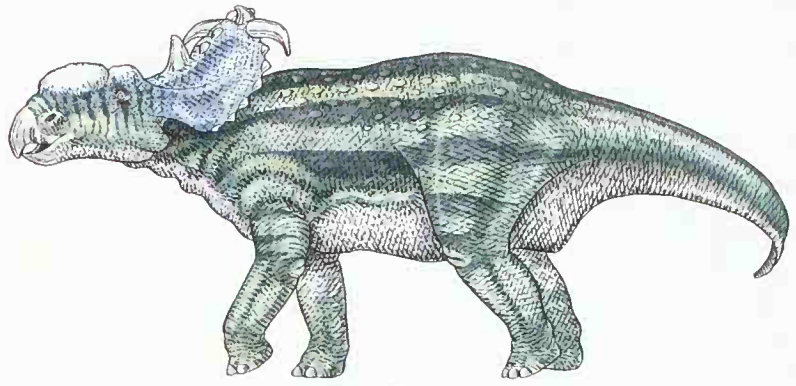
STYRACOSAURUS
Length: 18 ft (5.5 m)



TOROSAURUS
Length: 25 ft (7.6 m)



EUCENTROSAURUS
Length: 20 ft (6.1 m)



PACHYRHINOSAURUS
Length: 18 ft (5.5 m)

## SKELETON OF TRICERATOPS

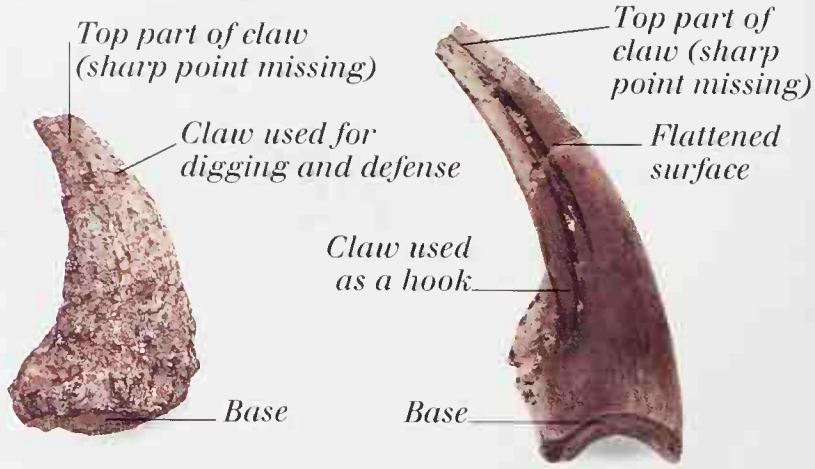
*Dorsal vertebrae*
*Parietosquamosal frill*
*Cranium*
*Orbit*
*Brow horn core*
*Rib*
*Scapula*
*Humerus*
*Cervical rib*
*Coracoid*
*Shoulder joint*
*Nose horn core*
*Naris*
*Infratemporal fenestra*
*Sternal bone*
*Ulna*
*Jugal bone*
*Rostral bone*
*Elbow joint*
*Tooth*
*Wrist joint*
*Radius*
*Phalanges*
*Mandible*
*Metacarpals*
*Predentary bone*

# Hands and claws

FOSSIL OF DINOSAUR CLAW

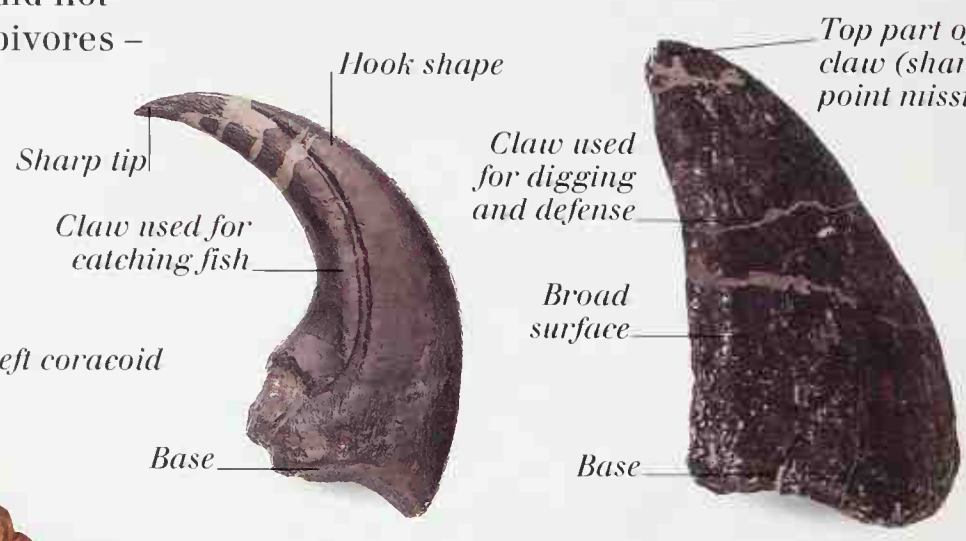
THE HANDS OF CARNIVOROUS (flesh-eating) dinosaurs – *Deinocheirus* and *Baryonyx*, for example – typically had three fingers (although a few had two), each tipped with a sharp claw. Many carnivorous dinosaurs also had opposable fingers that enabled them to grasp. They walked on their hind legs, leaving their arms and hands free to attack prey. However, the arms of some carnivores, notably *Tyrannosaurus*, were so short that they did not even reach their mouths. Most herbivores (plant-eaters) had padded hands with four or five fingers, tipped with claws or blunt nails. Many herbivores also had sharp thumb claws for digging or defense. Unlike carnivores, herbivores did not generally have opposable fingers. Although many herbivores – *Iguanodon* and *Prosaurolophus*, for example – had strong, weight-bearing forelimbs, such dinosaurs could also walk or run on their hind legs alone.

**EXAMPLES OF DINOSAUR CLAWS**


Top part of claw (sharp point missing)
Claw used for digging and defense
Base
Top part of claw (sharp point missing)
Flattened surface
Claw used as a hook
Base

MASSOSPONDYLUS THUMB CLAW

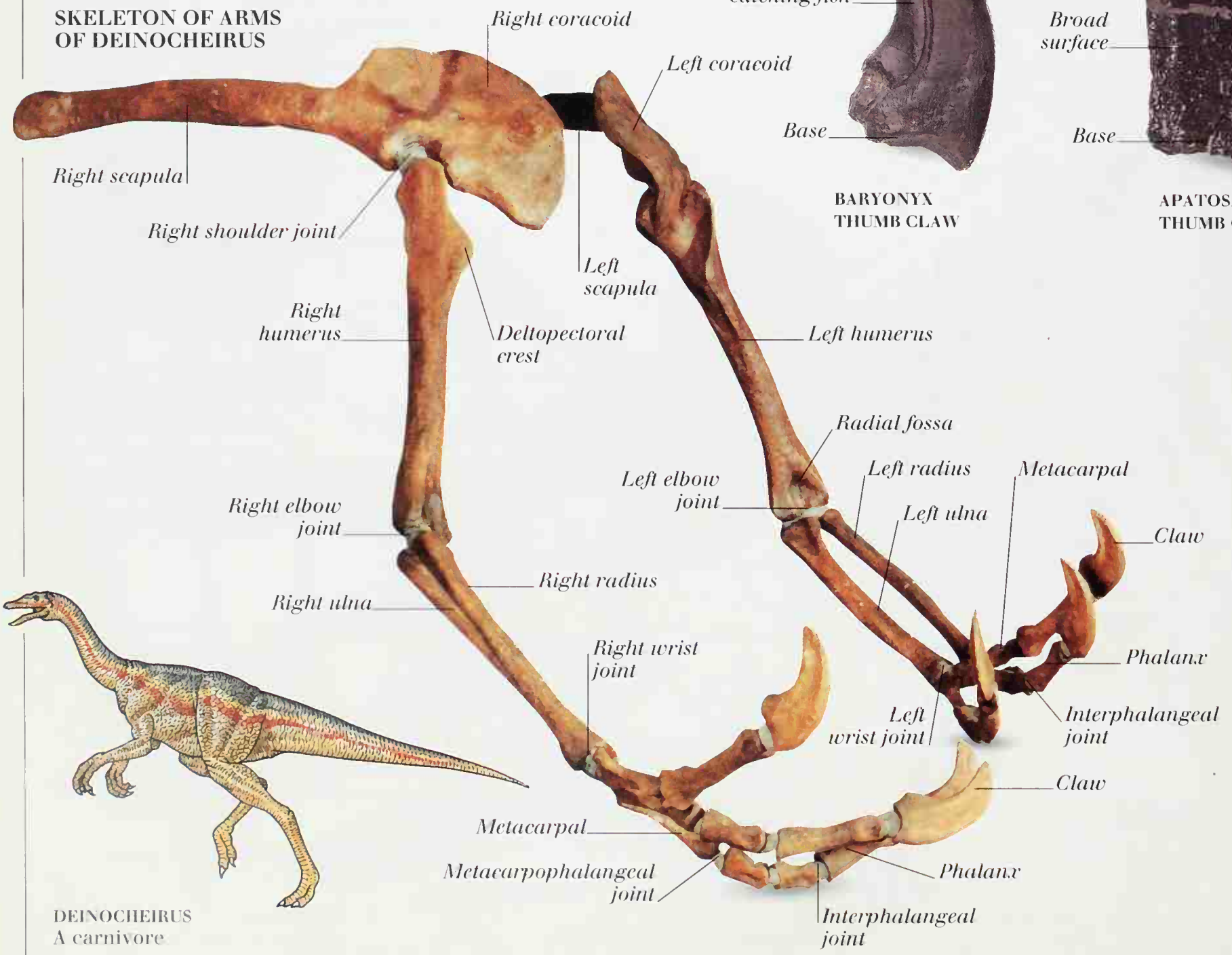
ORNITHOMIMUS FINGER CLAW




BARYONYX THUMB CLAW

APATOSAURUS THUMB CLAW

**SKELETON OF ARMS OF DEINOCHEIRUS**

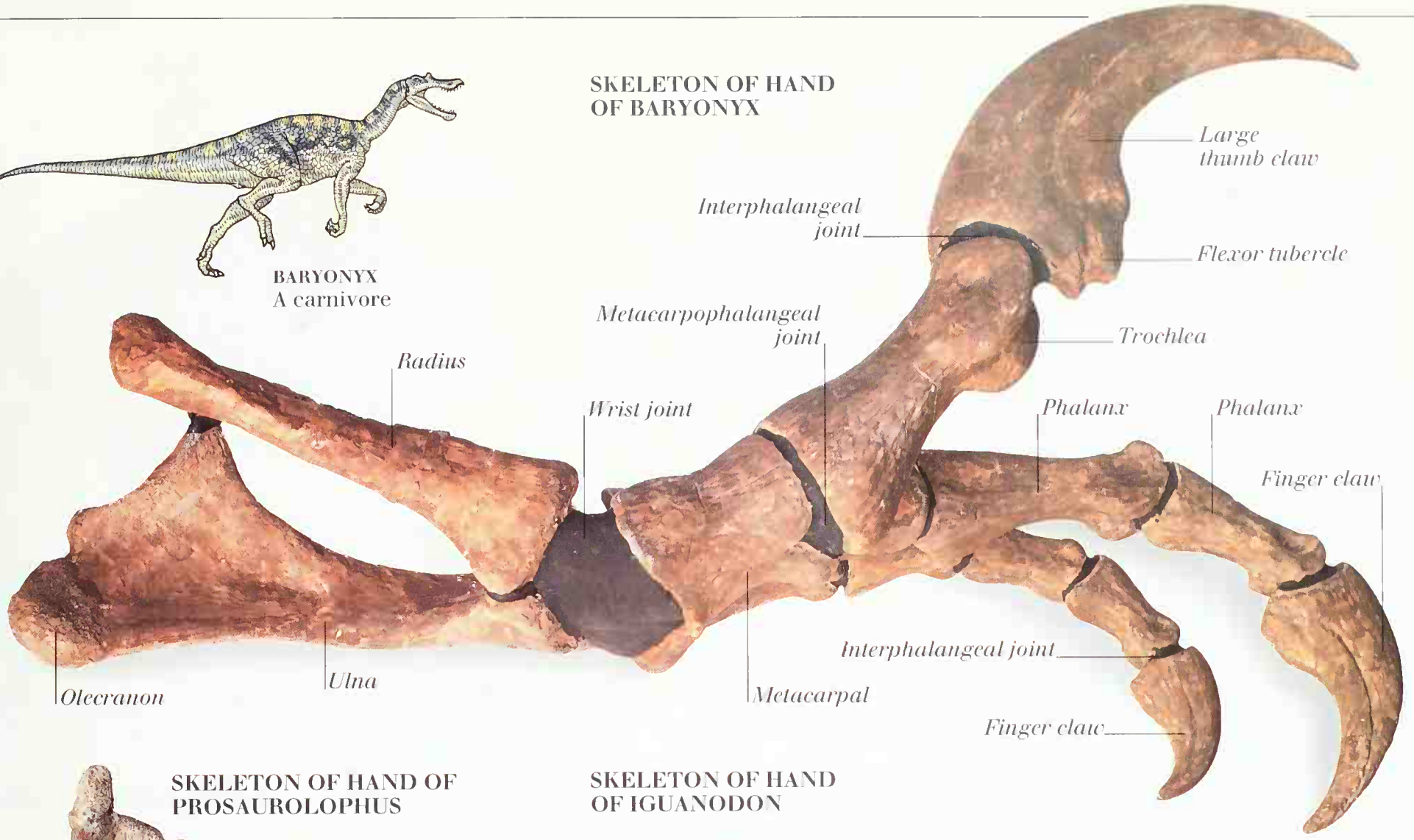




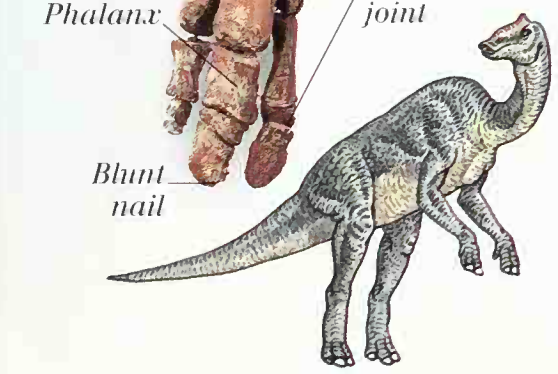

DEINOCHEIRUS
A carnivore

BARYONYX
A carnivore

SKELETON OF HAND OF BARYONYX

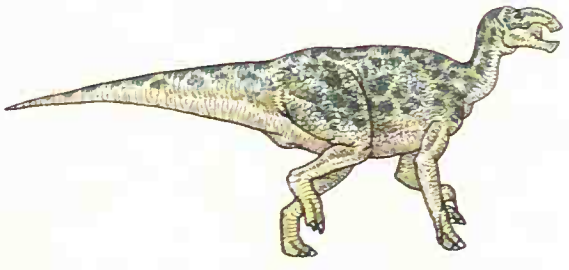



SKELETON OF HAND OF PROSAUROLOPHUS



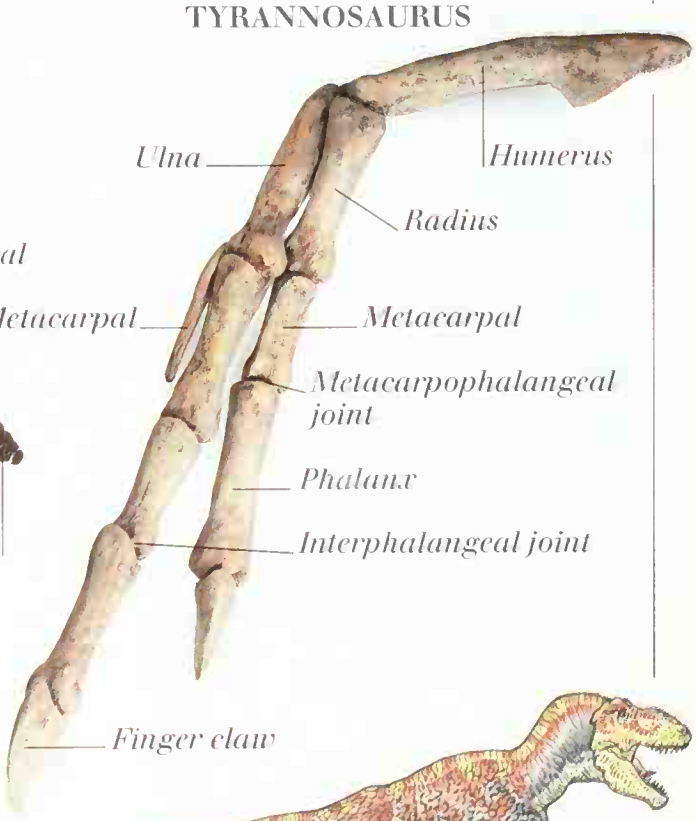
PROSAUROLOPHUS
A herbivore

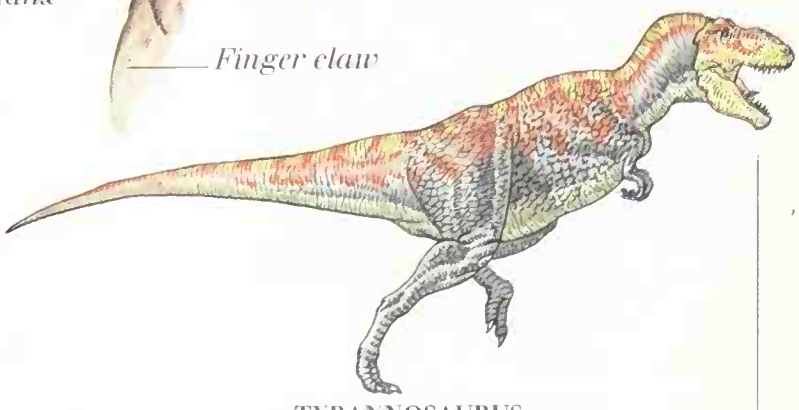
SKELETON OF HAND OF IGUANODON



IGUANODON
A herbivore

SKELETON OF ARM OF TYRANNOSAURUS



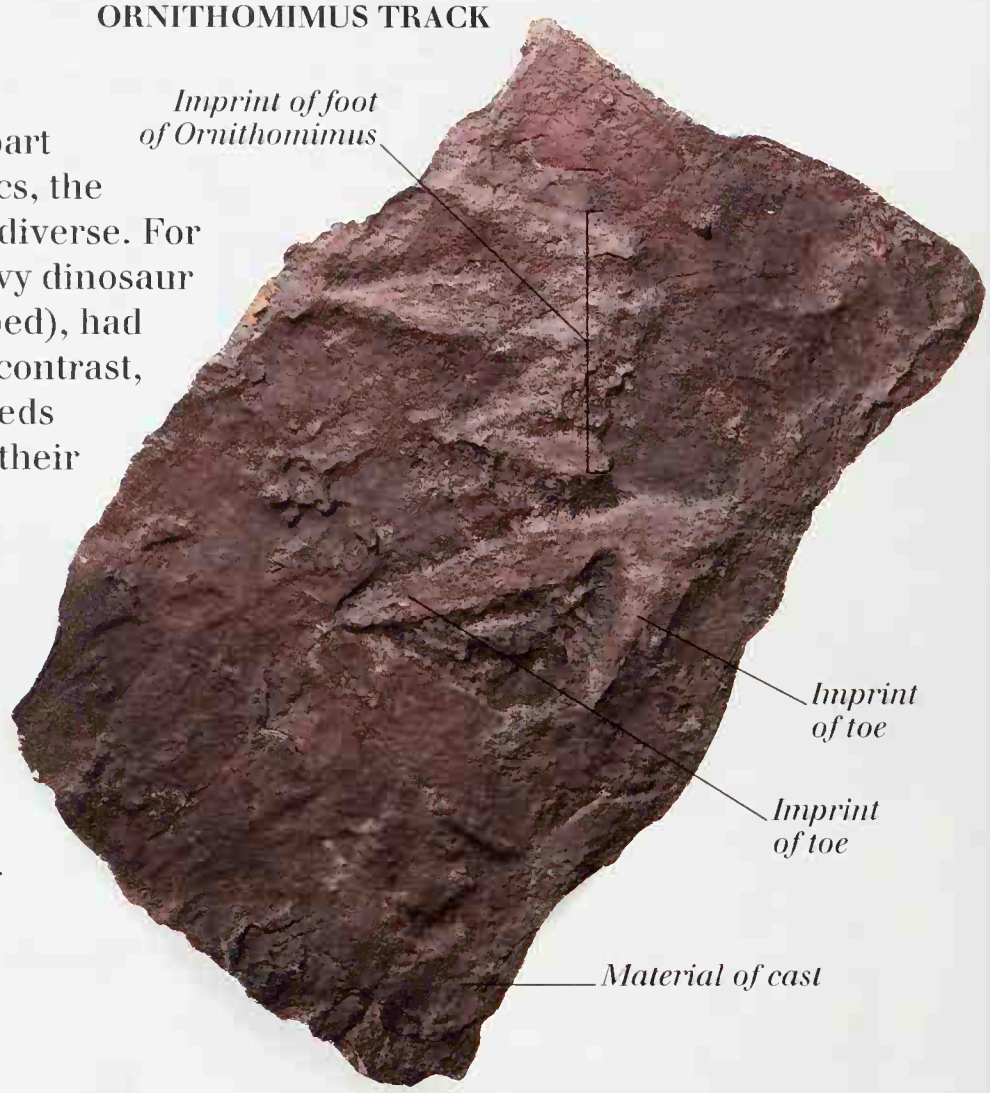
TYRANNOSAURUS
A carnivore

# Feet and tracks

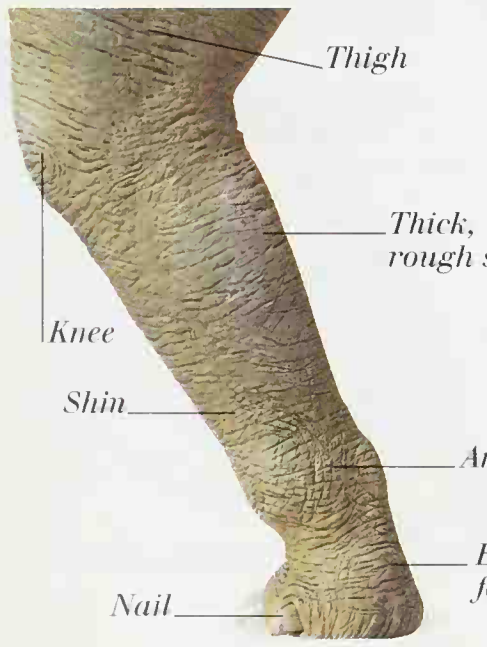
SKELETON OF FOOT OF PLATEOSAURUS

DINOSAURS HAD HIGH ankles and walked on their toes. However, apart from these common characteristics, the feet of dinosaurs were extremely diverse. For example, *Stegosaurus*, a large, heavy dinosaur that walked on all fours (a quadruped), had broad, short, elephant-like feet. In contrast, certain large, heavy, semi-quadrupeds (quadrupedal dinosaurs that sometimes walked or ran on their hind legs), such as *Parasaurolophus* and *Iguanodon*, had longer feet with separate toes. Smaller, lighter dinosaurs that walked on two legs (bipeds), such as *Chirostenotes*, *Compsognathus*, and *Dromiceiomimus*, had relatively long, narrow, birdlike feet. The fossilized tracks of some dinosaurs indicate not only the structure of their feet, but also how they moved. For example, the tracks of *Ornithomimus* confirm that it was bipedal, and also indicate that it was lightweight and could run quickly.

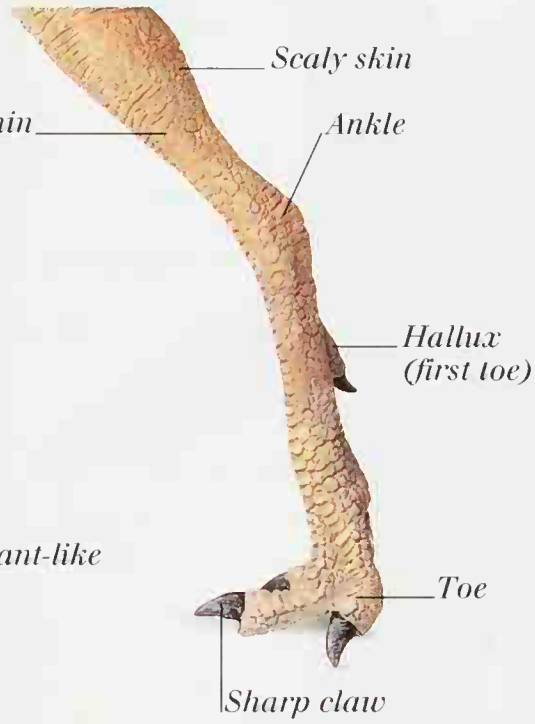
**CAST OF FOSSILIZED ORNITHOMIMUS TRACK**



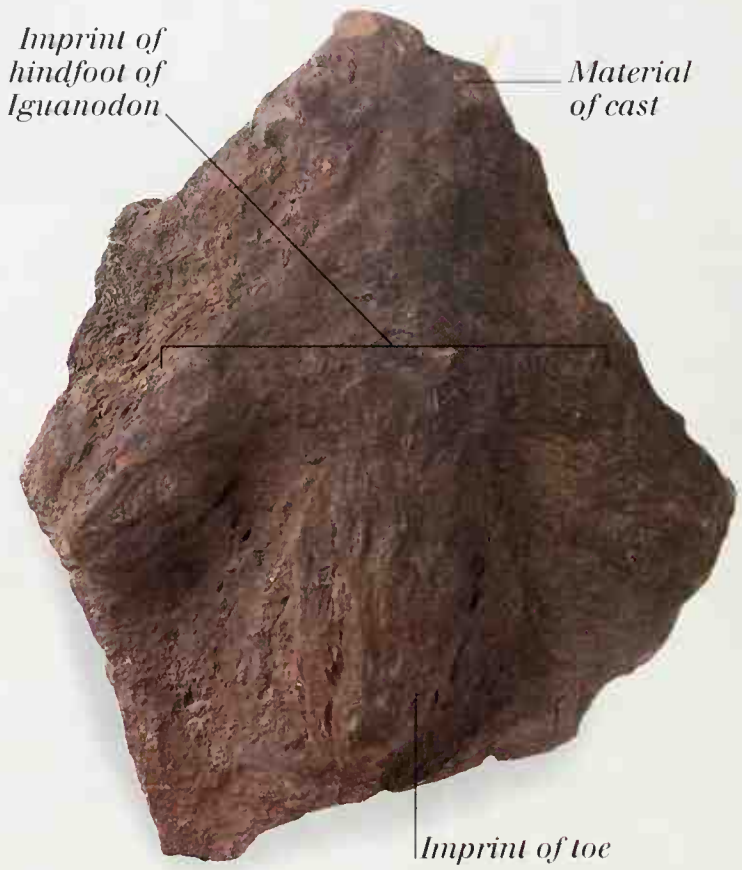

**FOOT OF STEGOSAURUS**



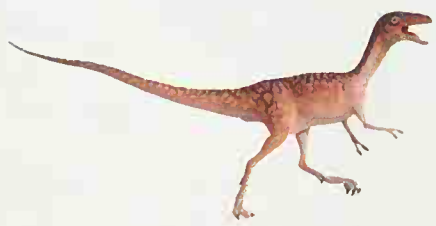

**FOOT OF COMPSOGNATHUS**




**CAST OF FOSSILIZED IGUANODON TRACK**

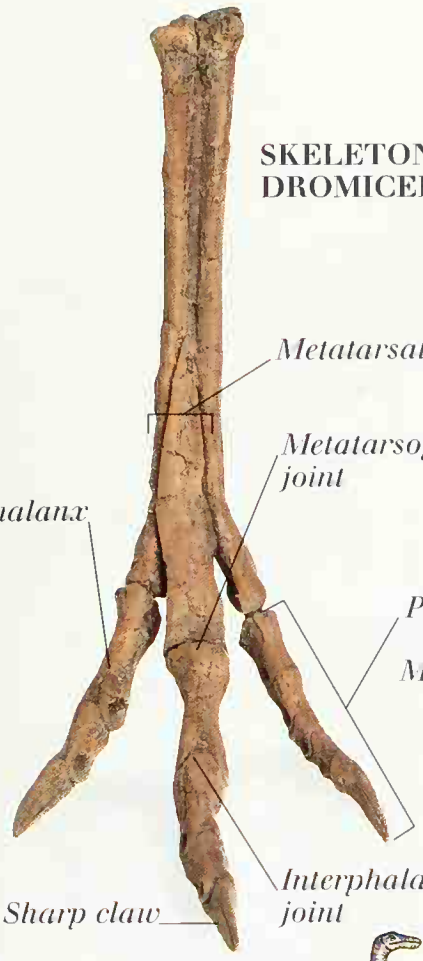


STEGOSAURUS
Length: 30 ft (9.1 m)



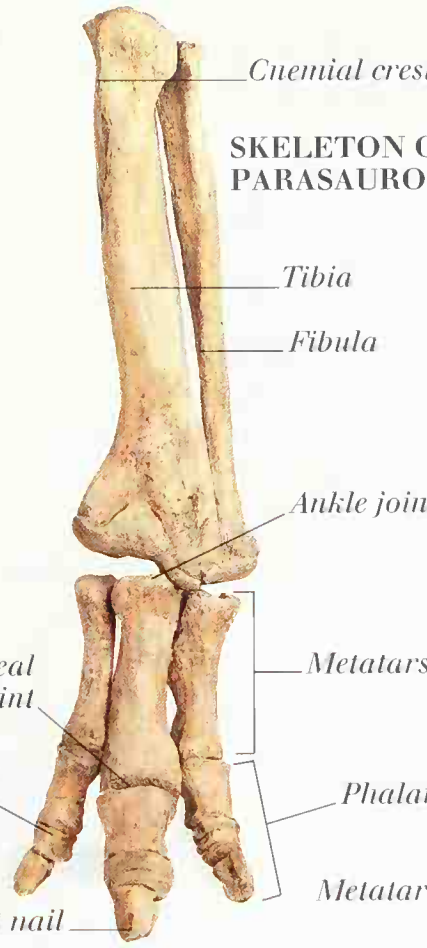
COMPSOGNATHUS
Length: 28 in (70 cm)

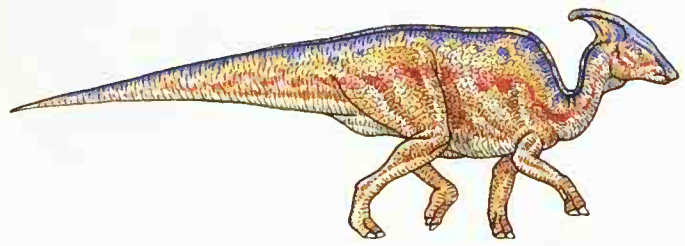
## SKELETON OF FOOT OF DROMICEIOMIMUS



DROMICEIOMIMUS
Length: 11 ft 6 in (3.5 m)

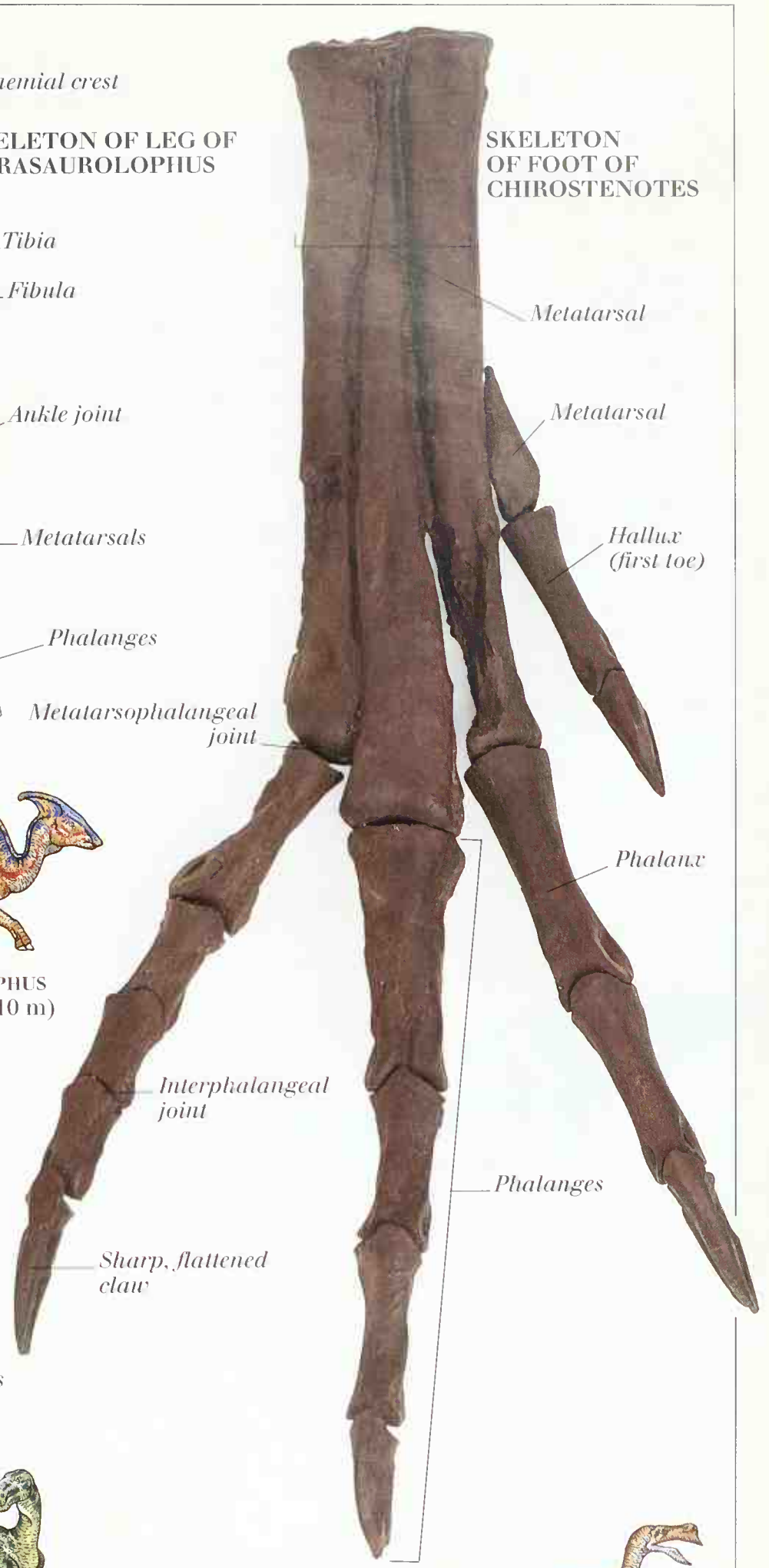
## SKELETON OF LEG OF PARASAUROLOPHUS

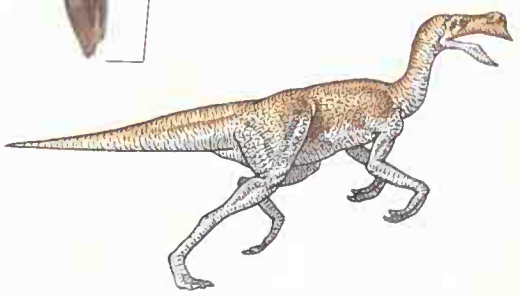


PARASAUROLOPHUS
Length: 33 ft (10 m)

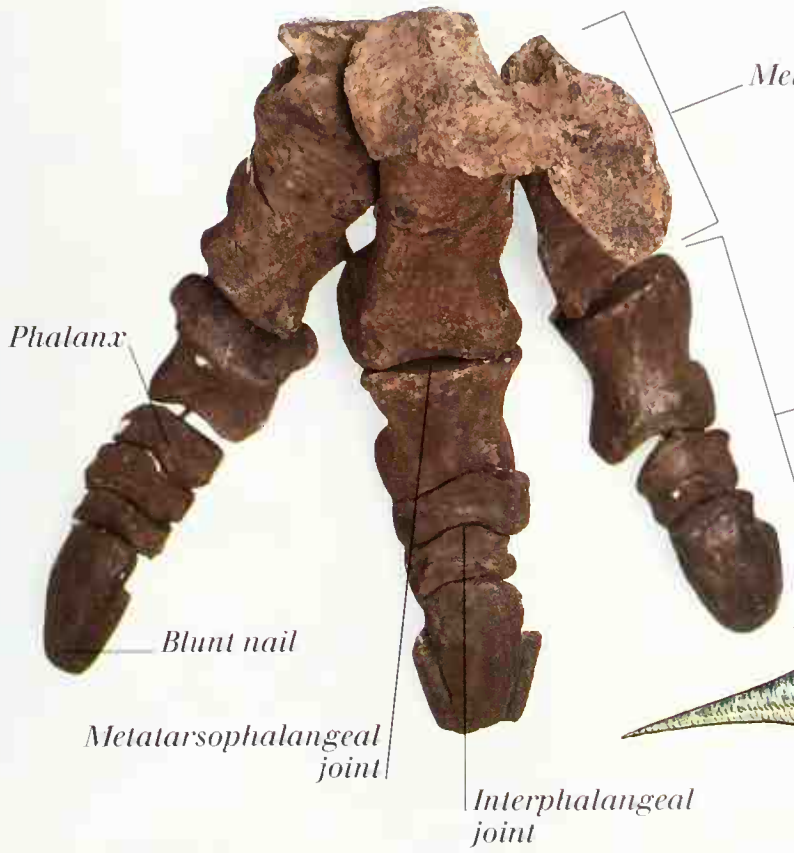
## SKELETON OF FOOT OF CHIROSTENOTES

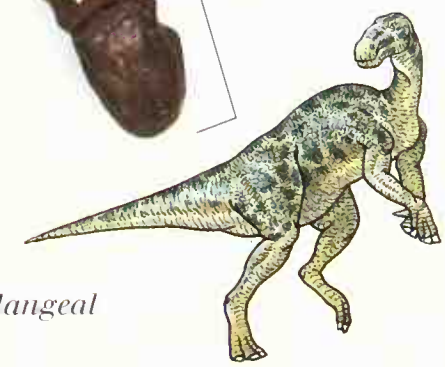


CHIROSTENOTES
Length: 6 ft 6 in (2 m)

## SKELETON OF FOOT OF IGUANODON



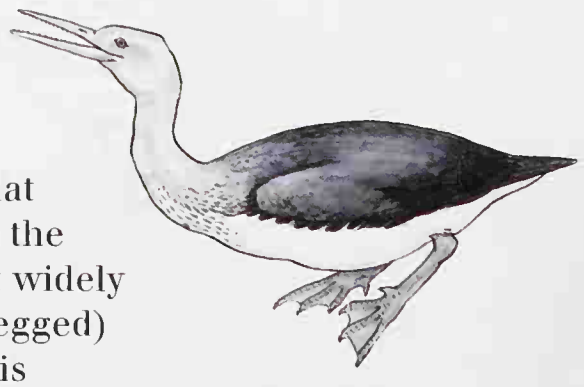



IGUANODON
Length: 30 ft (9.1 m)

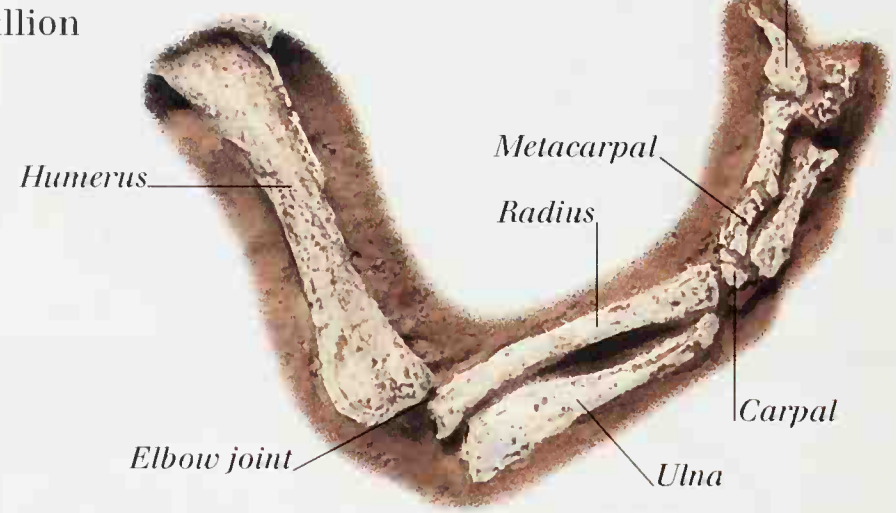
# Dinosaur relatives

FOSSIL OF A BIRD'S FEATHER

MOST DINOSAURS BECAME EXTINCT about 65 million years ago. However, modern birds are considered to be living dinosaurs, while crocodiles are generally thought to be the dinosaurs' closest living relatives. It has been suggested that birds and dinosaurs diverged from a common ancestor during the Early Jurassic (208–188 million years ago). However, the most widely accepted view is that birds evolved from small, bipedal (two-legged) dinosaurs, such as *Deinonychus*. The principal evidence for this relationship is the similarity between the limb bones of *Coelophysis*, *Archaeopteryx* (the oldest known bird), and modern birds: all have forelimbs with three digits, and hindlimbs with four toes, one of which is a reversed hallux (first toe). Possibly descended from *Archaeopteryx* were *Ichthyornis* and *Hesperornis*, both birds of the Late Cretaceous (97.5–65 million years ago), and the more modern (but extinct) *Diatryma*, *Paleospheniscus,* and *Presbyornis*, as well as present-day birds. Crocodiles are only remotely related to the dinosaurs, because the two groups evolved along different lines after splitting off from a common ancestral group during the Early Triassic (248–243 million years ago).



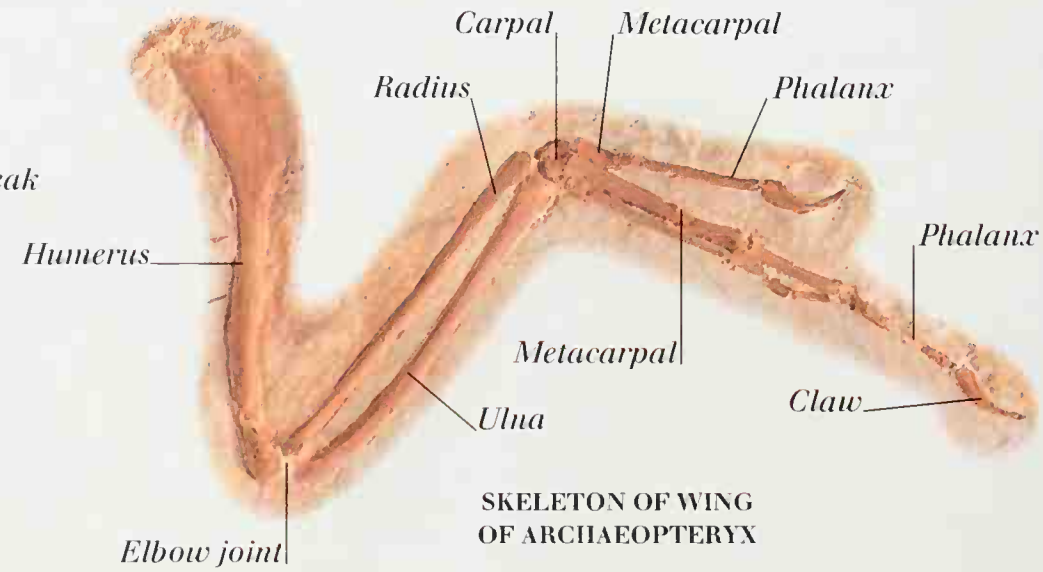
HESPERORNIS REGALIS
Length: 6 ft (1.8 m)



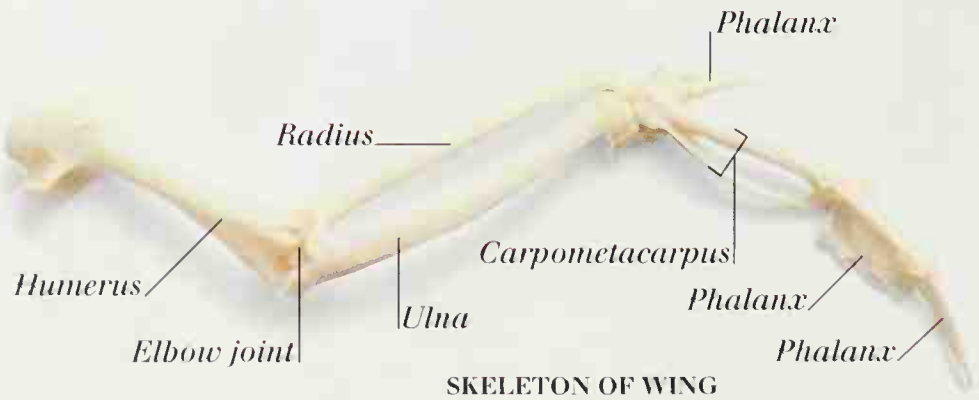

EVOLUTION OF A BIRD'S WING

SKELETON OF FORELIMB OF COELOPHYSIS

EXTERNAL FEATURES OF ARCHAEOPTERYX




SKELETON OF WING OF ARCHAEOPTERYX




SKELETON OF WING OF MODERN BIRD

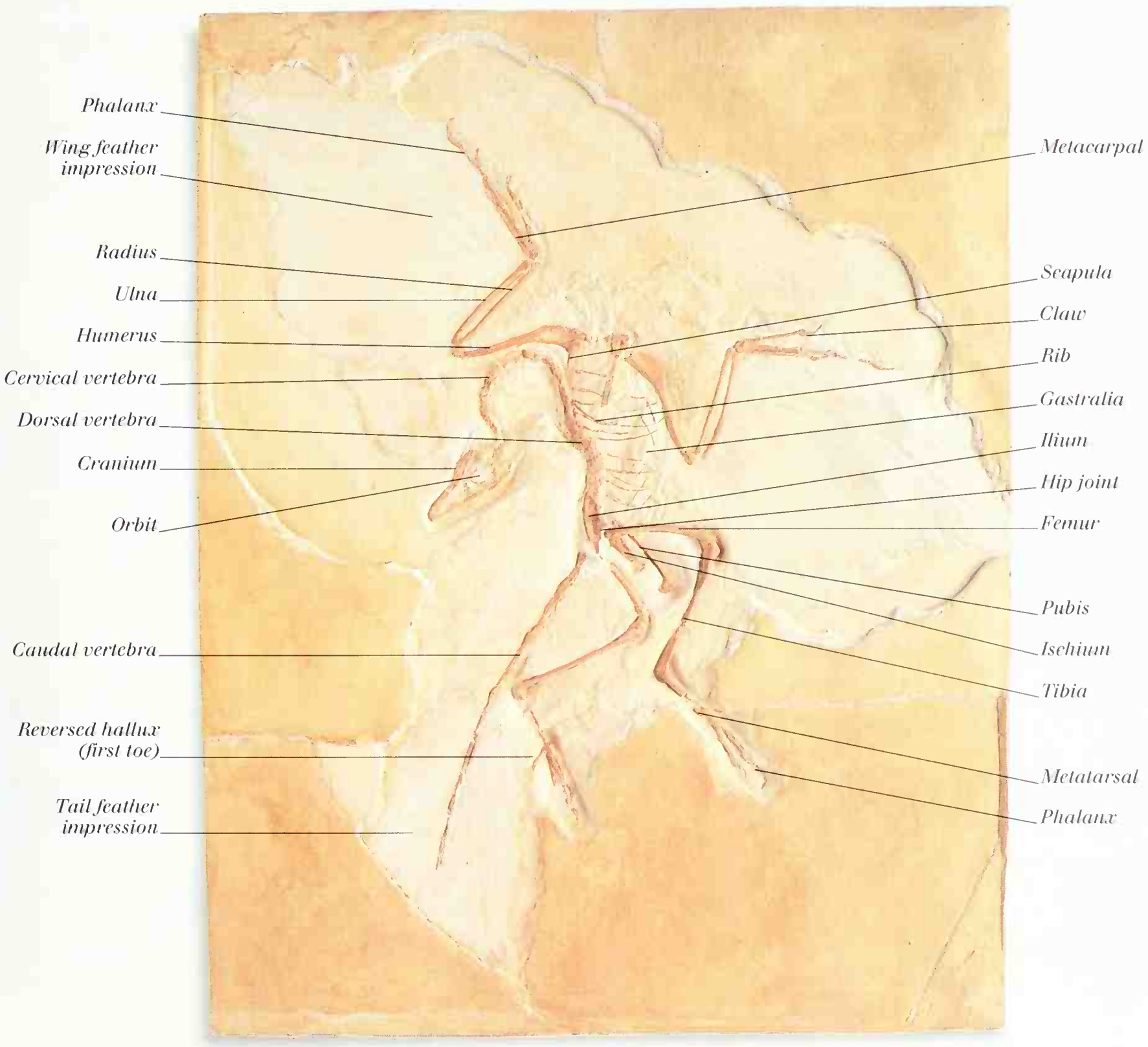
## EXAMPLES OF EXTINCT BIRDS

**PRESBYORNIS PERVETUS**
Height: 3 ft 3 in (1 m)

**PALEOSPHENISCUS PATAGONICUS**
Height: 26 in (66 cm)

**ICHTHYORNIS DISPAR**
Length: 8 in (20 cm)

**DIATRYMA GIGANTEA**
Height: 7 ft (2.1 m)




**FOSSIL SKELETON OF ARCHAEOPTERYX**

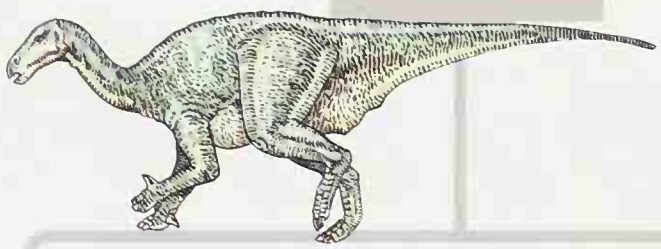
# Dinosaur classification

THE CLASSIFICATION OF DINOSAURS is controversial and is continually being revised in the light of new fossil finds and reinterpretations of existing evidence. There are also a number of different methods of classification. The method used here is based on inherited features shared by members of a group but not by any members in other groups. According to this classification, all dinosaurs and their relatives belong to the major group Archosauria (ruling reptiles). The Archosauria can be split into two main divisions: primitive archosaurs, which include Proterosuchia, Erythrosuchia, *Euparkeria*, and Crurotarsi; and ornithodiran archosaurs, which include Pterosauria, *Lagosuchus*, and the Dinosauria. The Dinosauria ("true" dinosaurs) can be divided in turn into three groups: Herrerasauria (early predatory dinosaurs), Saurischia (lizard-hipped dinosaurs), and Ornithischia (bird-hipped dinosaurs). Each group can then be subdivided down to the levels of families (with names ending in "-idae"), genera (indicated by italics in this chart), and species.

**KEY**

- ARCHOSAURS (RULING REPTILES)
- PRIMITIVE ARCHOSAURS
- ORNITHODIRAN ARCHOSAURS
- FLYING ARCHOSAURS
- DINOSAUR-LIKE ARCHOSAURS
- DINOSAURS
- EARLY PREDATORY DINOSAURS
- LIZARD-HIPPED DINOSAURS
- BIRD-HIPPED DINOSAURS

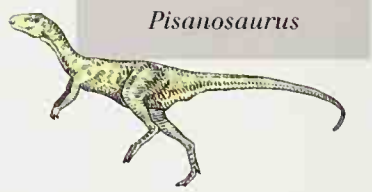
ORNITHISCHIA

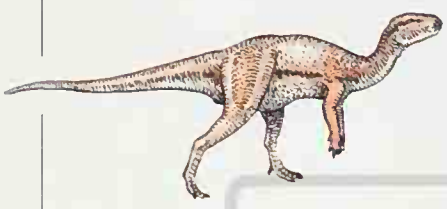


CERAPODA

THYREOPHORA

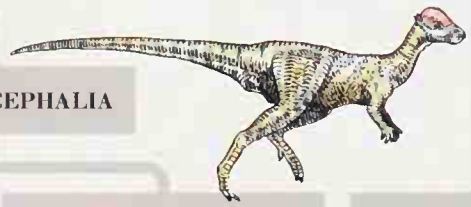
*Pisanosaurus*





*Lesothosaurus*

MARGINOCEPHALIA



STEGOSAURIA

ANKYLOSAURIA

ORNITHOPODA

CERATOPSIA

PACHYCEPHALOSAURIA

*Scelidosaurus*
*Scutellosaurus*

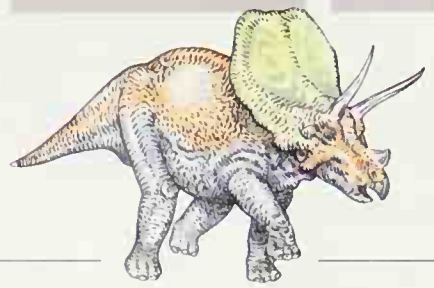
Huayangosauridae
Stegosauridae

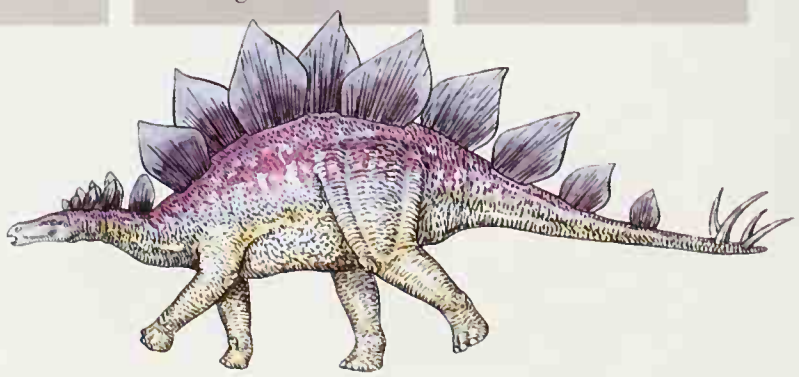
Ankylosauridae
Nodosauridae

Camptosauridae
Dryosauridae
Hadrosauridae
Heterodontosauridae
Hypsilophodontidae
Iguanodontidae

Ceratopsidae
Protoceratopsidae
Psittacosauridae

Chaoyoungosauridae
Homalocephalidae
Pachycephalosauridae





# ARCHOSAURIA

PARASUCHIA

PROTEROSUCHIA

*Euparkeria*

ORNITHOSUCHIDAE

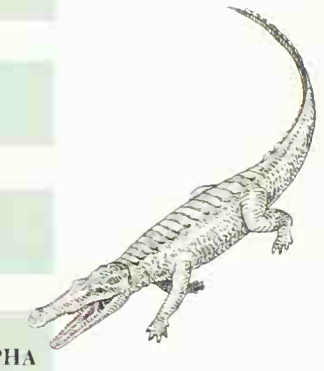
CRUROTARSI

AETOSAURIA

ERYTHROSUCHIA

ORNITHODIRA

RAUISUCHIA



PTEROSAURIA

DINOSAURIA

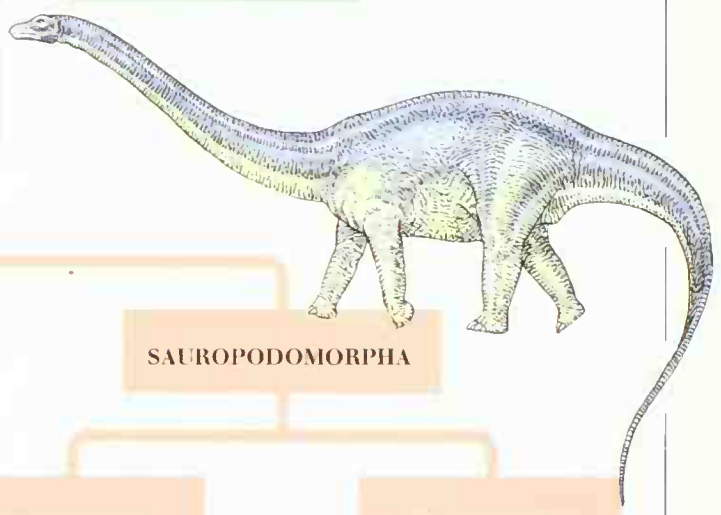
*Lagosuchus*

POPOSAURIA

HERRERASAURIA

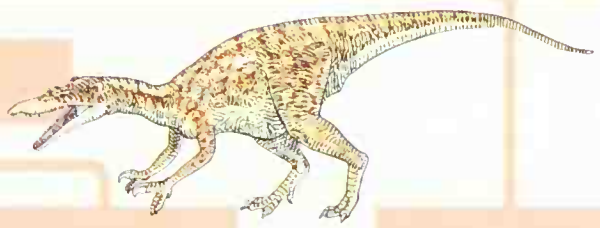
CROCODYLOMORPHA

*Herrerasaurus*
*Staurikosaurus*



SAURISCHIA

THEROPODA



SAUROPODOMORPHA

CERATOSAURIA

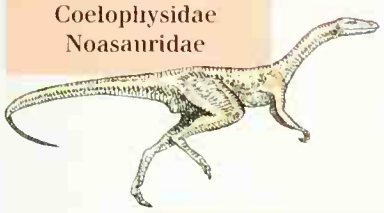
TETANURAE

SEGNOSAURIA

PROSAUROPODA

SAUROPODA

Abelisauridae
Alvarezsauridae
Ceratosauridae
Coelophysidae
Noasauridae



Enigmosauridae
Segnosauridae

Anchisauridae
Blikanasauridae
Melanorosauridae
Plateosauridae
Yunnanosauridae

Barapasauridae
Brachiosauridae
Camarasauridae
Cetiosauridae
Dicraeosauridae
Diplodocidae
Euhelopodidae
Titanosauridae
Vulcanodontidae

Haltiosauridae

CARNOSAURIA

COELUROSAURIA

AVES

DEINONYCHOSAURIA

ORNITHOMIMOSAURIA

OVIRAPTOROSAURIA

Allosauridae
Aublysodontidae
Baryonychidae
Dryptosauridae
Itemiridae
Megalosauridae
Spinosauridae
Torvosauridae
Tyrannosauridae

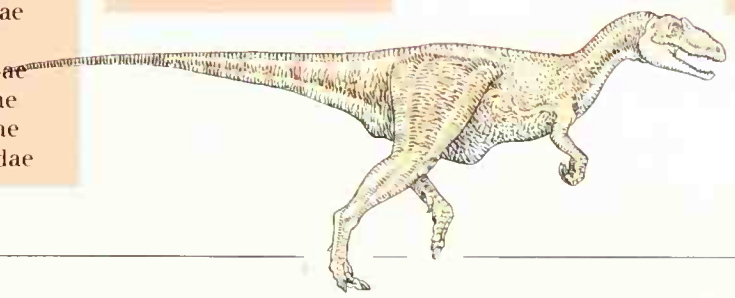
Avimimidae
Coeluridae
Compsognathidae

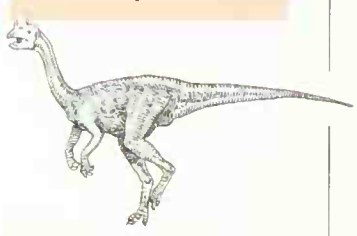
Archaeopterygidae

Dromaeosauridae
Therizinosauridae
Troodontidae

Deinocheiridae
Garudimimidae
Ornithomimidae

Caenagnathidae
Ingeniidae
Oviraptoridae





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